AGRICULTURAL ENGINEERING

Established 1920

This journal is owned, edited, and published monthly by the American Society of Agricultural Engineers.

Editorial and advertising departments at the executive office of the Society, Saint Joseph, Michigan. Publication office at Benton Harbor, Michigan.

RAYMOND OLNEY
Editor

RALPH A. PALMER
Associate Editor

OFFICERS AND COUNCIL
OF THE A.S.A.E.

KARL J. T. EKBLAW . . *President*
R. H. DRIFTMIER . *Vice-President*
F. P. HANSON . . *Vice-President*
G. A. RIETZ . . . *Vice-President*
B. D. MOSES . . . . *Councilor*
J. C. WOOLEY . . . . *Councilor*
C. E. RAMSER . . . . *Councilor*
S. P. LYLE . . . *Past-President*
A. P. YERKES . . . *Past-President*

RAYMOND OLNEY . . *Sec'y-Treas.*

The A.S.A.E. is a member of
AMERICAN ENGINEERING COUNCIL
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
AUDIT BUREAU OF CIRCULATIONS

ADVERTISING REPRESENTATIVES

Chicago: DWIGHT H. EARLY
100 North LaSalle St.
Telephone: Central 4158

New York: A. M. WILLCOX
420 Lexington Ave.
Tele.: LEXington 2-4816

SUBSCRIPTION PRICE: To non-members of the A.S.A.E., $3.00 a year in the U. S. and possessions and in Americo-Spanish countries, $3.50 a year in Canada, and $4.00 a year in all other countries; to A.S.A.E. members anywhere, $2.00 a year. Single copies (current), 30 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

The American Society of Agricultural Engineers is not responsible for statements and opinions advanced in its meetings or printed in its publications; they represent the views of the individuals to whom they are credited and are not binding on the Society as a whole.

TITLE: The title AGRICULTURAL ENGINEERING is registered in the United States Patent Office.

COPYRIGHT: Copyright, 1940, by the American Society of Agricultural Engineers.

CONTENTS FOR MARCH 1940

Volume 21, Number 3

EDITORIALS 85

THE USE OF ELECTRIC LIGHT TRAPS IN THE CONTROL OF THE EUROPEAN CORN BORER 87
By G. A. Ficht, T. E. Hienton, and J. M. Fore

AN APPROACH TO THE FARM BUILDINGS PROBLEM 90
By K. K. King

A NEW DEVICE FOR LAYING OUT CONTOUR LINES 91
By L. H. Schoenleber

SOME ASPECTS OF MECHANIZATION IN AMERICAN ECONOMY 93
By Harry G. Davis

TRANSPORT WHEELS FOR AGRICULTURAL MACHINES: V. Effect of Wheel Arrangement on Rolling Resistance 95
By Eugene G. McKibben and J. Brownlee Davidson

PROGRESS TOWARD A STANDARD TRACTOR FUEL 97

AN ANALYSIS OF DEGREE AND LENGTH OF SLOPE DATA AS APPLIED TO TERRACING 99
By Austin W. Zingg

INSTRUMENTS FOR HYDROLOGIC RESEARCH 102
By W. H. Pomerene

THE FARM HOUSE AND THE ARCHITECT 103
By Fred M. Overby

SINGLE VERSUS DUAL PNEUMATIC TIRES 105
By E. C. Sauve

DRAINAGE INVESTIGATIONS OF THE FARM CREDIT ADMINISTRATION 107
By Don H. Bushnell

ENGINEERING ASPECTS OF HANDLING FARM CHEMURGIC CROPS 110
By H. E. Barnard

NEWS 113

AGRICULTURAL ENGINEERING DIGEST 114

General-Purpose Tractor Application

NOW that the general-purpose tractor has been highly developed as a soundly engineered power unit, getting it used to the maximum profitable extent depends on accurate agricultural-engineering analysis and explanation of its economic field. Its use shown above, to move a portable loading ramp, suggests its use on incidental farm jobs to save time and money directly, and to add to the hours of annual use which share the investment cost. If full advantage is to be taken of the hair-splitting engineering exercised in the development and production of these tractors, it must be followed by corresponding refinement in the mechanics and economics of their use.

What farm jobs come within the power and ground-speed range of various sizes of general-purpose tractors? At what frequency, at what specific or optional times, for what durations, and at what different locations on the farm do these power requirements exist for different types, scales, and conditions of farm operation? What is their relative importance? To what extent do their time requirements overlap?

On these jobs how does the direct power, labor, and crop-yield or work-result economy of the general-purpose tractor compare with the corresponding economy of other possible power units? To what extent can these jobs be handled by one general-purpose tractor with investment and operating economy sufficient to give maximum overall economy? Where is the dividing line between what can be done most economically with a general-purpose tractor and what can be done more economically with some other power unit? It will differ for individual farms and farmers, but applicable principles for the guidance of farmers can be further developed. Development of principles and application data governing the mechanics and economics of farm power application is an agricultural-engineering job.

AGRICULTURAL ENGINEERING

VOL 21, NO 3 EDITORIALS MARCH 1940

Engineering and Progress

IN A world of complexity, misunderstanding, and distrust, it behooves engineers to review frequently their philosophy in order to insure their continued confidence in the merits of their profession; to give that understanding and confidence to the oncoming generation of engineers; and to minimize public misunderstanding of and secure their cooperation with engineering objectives and activities.

Such criticism and condemnation as is aimed at engineers is based on two widely differing and inconsistent viewpoints. On one extreme, engineers are criticized for their materialism, their devotion to worldly progress, their lack of culture in the higher arts of living. On the other extreme, they are criticized because their methods, agencies, and results do not quickly solve all the world's problems, or prevent new problems from arising.

Engineers are dedicated to material progress. Some may see that as a worth-while end in itself. Many others see it as a means to higher human and spiritual objectives.

Except for the comparatively few who dedicate their lives exclusively to spiritual things, or to knowledge, the arts, or pleasure for its own sake, all people are concerned with material welfare and progress for themselves, for some small or large group of which they are a part, or for humanity in general. They differ only in the breadth of their interests, their ideas of what constitutes progress, their methods of working, their effectiveness, and their outlook on material considerations. Some idealists see material considerations as necessary evils, to be forgotten whenever possible in contemplation and enjoyment of the "higher things of life." Engineering idealists, on the other hand, are apt to be realists enough to see material things as a challenging part of the art and drama of mental and spiritual, as well as physical life.

The engineering concept of material progress has moral and spiritual significance. It puts a premium on intellectual honesty and personal integrity. It worships no idols in the form of dreams of a worldly Utopia. It encourages intelligent respect for such mysteries, infinities, and intangibles of nature as space, time, force, life, and spirit. It recognizes creation and organization in the universe infinitely beyond the capacity of man. In their work of utilizing the forces and materials of nature for the benefit of man, engineers follow the teaching of the biblical parable of the talents. Engineering does not eliminate the inequalities of fate's dealings with men, but it helps humanity to progress "en masse" to richer lives.

Engineering is partly an art. It is an outgrowth of several arts. It uses several arts. It exercises the artistic quality of originality. It is an aid to the "higher" arts, directly in the improvement of some of the tools, materials, and forces used in various arts; and indirectly in freeing a larger proportion of the population from economic pressure, giving them more time and means to study, practice, and enjoy the "higher" arts. In the same manner it contributes to science, education, government, and other progressive or positive aspects of civilization as we understand it. It supports the combined merit of mental and physical creativeness.

It is true that engineering methods, agencies, and results are sometimes misused, by some few engineers and by others, deliberately to serve selfish ends, or through misunderstanding and lack of information, preventing the realization of their full potential value to humanity. But to condemn engineering on this basis is to condemn all resources and knowledge as equally susceptible to misinterpretation and misuse.

Engineering progress sometimes works hardships on individuals, but the lack of it in times past and in other places has worked hardships on many more.

It has been seriously suggested in recent years that a moratorium be declared on scientific and engineering progress, to allow other aspects of civilization time to catch up. This amounts to asking for a limitation on the free exercise of human thought, on free speech, a free press, and free enterprise. There is considerable evidence that it would react unfavorably on employment, commerce, education, the arts, and on the very progress of the other aspects of civilization on which it waited. There are whole areas and nations where the rate of technical progress has been less rapid than in the United States, and they may be better off than we by some standards, but we notice no great pressure of emigration from the United States to those places. The idea is not consistent with the beliefs, principles, or desires of our people.

Considering these things, can it be said honestly or correctly that engineers are too materialistic; or that their contributions to humanity are merely accidents incidental to the worldly machinations of an uncultured proletariat? Engineering is a culture of human spiritual, mental, and physical progress through effective use of worldly resources.

Those who criticize engineering for what it has not done fall short of practical realism, or even idealism, as to human nature, the nature of human problems and progress, and the nature of engineering.

Engineering has not solved all the world's problems, or prevented new problems from arising, and never will, because problems arise in the minds of men, whenever their desires, ambitions, or aspirations meet obstacles in the realities of nature or the conflicting interests of other men. Engineers solve problems, not in order that less problems will remain to be solved in the future, but in order that men may progress to higher aspirations, greater achievements, and the hope of solving increasingly difficult problems.

The engineering method of thought and work has proven particularly effective in solving problems by applying the quantitative knowledge of certain branches of natural science, and in supplementing the work of scientists in developing such knowledge. No end to this work is in sight. The problems solved are mostly those created by natural obstacles to man's progress. Engineers have done some effective work, however, in solving problems created by the conflicting or competing interests of men. Together with the other professions and with science, commerce, and evolving concepts of human relationships, engineering has developed the most rapid rate of material progress known in history.

In some past times and in some places where hard times have been endured, man's problems have been largely those of overcoming the obstacles which nature has placed in the way of his aspirations.

Flood and drought in certain areas are examples of nature's contribution to the relative economic depression of the past decade, but the conflicting interests of men have

imposed greater obstacles and problems in the United States and some other countries during this period. A progressive view of the way to improve this situation is not to stop science and engineering from reducing the natural obstacles to progress, but to bring comparably effective attention and methods to bear on reducing unnecessary conflicts between the interests of men.

Engineers would be the last to claim perfection for their profession. The true engineering spirit is one of looking for and expecting to find opportunity for improvement in one's self and one's own work, as well as elsewhere in the world. Engineers are not all of one mind as to where and how they might work most effectively, but on one point they might agree. If, as suggested by his instinctive urges for a better life, man's earthly mission and destiny is progress in the achievement of difficult and worthy aspirations, then engineering work is justified wherever and whenever its methods may be most effective in the solution of the problems encountered.

After the War

WAR diverts manpower from farm production, and causes destruction of farm produced commodities and of farm production capacity. Herbert Hoover, from his outlook as an engineer and as an administrator of food and relief for war-torn countries, has predicted a serious world food shortage following and resulting from the current conflicts in Europe and Asia.

What does this mean to agriculture in this country, to our agricultural engineers, and to industries producing engineered equipment and materials for sale to farmers as aids to efficient production?

It will probably mean some increase in the export market for American farm products, and for farm production equipment, as and when the war-spent countries find the means to purchase these goods.

What may prove more important, it seems likely that any world food shortage which materializes will relieve American markets of some of the pressure of agricultural imports, at least temporarily.

The wars may last another year or several years. They may or may not be extended to other countries. They may be followed by reduced or increased economic nationalism. It seems quite certain, however, that they will stimulate agricultural production in all of the principal agricultural countries of the world, especially the noncombatants. After the war waste has ended and the temporary food shortage has been alleviated, there will probably be another period of readjustment of production capacity, with low prices for many farm products.

How can American farmers render maximum economic and humanitarian service in the period of food shortage, and at the same time improve their capacity to weather a subsequent depression?

A period of high prices for farm commodities is a good time for farmers to reduce debt. It is a good time to increase production, not by going in debt for more land at high prices, but by using improved methods and equipment. It is a good time to work toward a shift of production from world market staples that will be due for distress later, to domestic market specialties, the production of which has not been excessively stimulated by temporary high prices.

Prospective improvement in American farm prosperity, if and when the temporary food shortage becomes effective, possibly in another year or so, has immediate implications for agricultural engineers, and for the industries which produce engineered equipment and materials as aids to effective use of human effort on farms. Even two or three years is a short time to look and plan ahead in engineering work and industrial production, from the standpoint of having improved equipment and methods ready for use when an impending unusual demand becomes effective. If American farmers are to help minimize the possible world food shortage without being caught overextended when the shortage has passed, agricultural engineering research, work on equipment and method improvements, and extension work among farmers to increase effectiveness of farm labor all need to be intensified, beginning now. And the value of this work will not be lost, even if the prospective food shortage should fail to materialize. Increasing the effectiveness of human effort in meeting market demand is always sound economics.

"Engineered Farm Shops"

To the Editor:

SINCE seeing the feature page "Engineered Farm Shops" in AGRICULTURAL ENGINEERING for January, I have been thinking more about just what the role of the agricultural engineer should be in a program of improving farm shops and shop work as it is done generally on farms.

It would be fine to have an analysis of needs, statements of principles, samples of schedules, estimates of time requirements, etc., for various adjustments, repairs, and overhauling jobs that could be done profitably on the farm. I am inclined to believe, however, that such engineering service would be so far in advance of most of our farmers that only a small minority could benefit from it. Plans for simple structures and pieces of equipment not commercially available at low cost which might be built or assembled in the farm shop are already available to a limited degree. Such plans have been developed and distributed largely by agricultural colleges and extension services in response to definite needs, such as for improvised simple machines for bindweed control, portable sheep-dipping tanks, etc.

The greatest deterrent to a widespread improvement in shop work on farms generally, it seems to me, is the lack of shop ability and knowledge of shop work on the part of the farmer himself. Many agricultural engineers in college work are in position, I believe, to give definite support to programs of improved shop practices on farms in their states. In most states instruction in farm shop work is given in the high school vocational agricultural departments. This instruction has frequently been much less effective than it might have been, because of lack of funds for shop equipment in the schools, lack of suitable teaching materials, in some cases because of poor teaching methods, and in too many cases because of poorly prepared teachers who received their training in part in college departments of agricultural engineering.

The shop programs in the high schools have been centered, in the main, around practical projects which the boys make, many times without due regard to the fundamental shop processes or principles involved. Consequently, too often there have been rather unsatisfactory results from shop instruction in the high schools simply because it has not been definitely related to fundamental principles.

With the great need for improvment in shop work on the farm, and with the great opportunities offered for this improvement through the high school vocational agriculture programs, I think all agricultural engineers in college work should cooperate and lend their assistance wherever and whenever possible.

M. M. JONES

Professor of Agricultural Engineering,
University of Missouri.

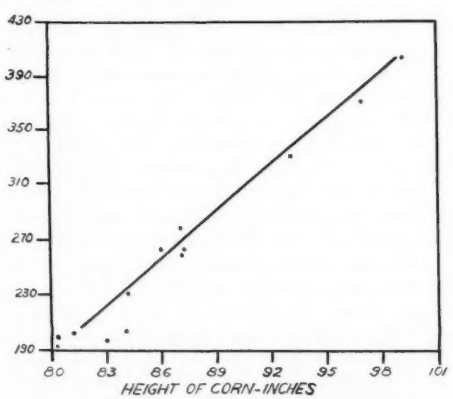
The Use of Electric Light Traps in the Control of the European Corn Borer

By G. A. Ficht, T. E. Hienton, and J. M. Fore
FELLOW A.S.A.E. JUNIOR A.S.A.E.

THE CHIEF recommendations at present for the control of the European corn borer in Indiana, have to do primarily with the destruction of corn crop residues, a process which, for practical results, requires the cooperative support of all corn growers in a locality. Other recommendations, cultural in character, provide means of reducing or avoiding damage on individual farms. The most important of these recommendations is delayed planting. Use of these cultural practices in control has been complicated in Indiana during recent years by the appearance of a partial second and third generation of the corn borer. The final result of these alterations in the seasonal development of the pest has been a lessening of the degree of control obtained by changing planting dates, as the second generation now attacks the later plantings. Second-generation borers become full grown too late in the season to affect greatly the yield of dent corn, but they seriously complicate the problems of the sweet-corn growers who commonly make a series of plantings on various dates, both for canning and market use. The only means of protection now available in these instances is the use of insecticidal sprays or dusts, the former being the more satisfactory. Studies of control with lights were initiated in the hope of finding an additional means of control that could be used to advantage by the individual grower.

Our preliminary studies on light for attracting European corn borer moths consisted of a high concentration of lamps to determine whether or not the moths could be captured or oviposition prevented. The total wattage used was 2000 per acre. This resulted in the almost complete elimination of borer infestation within the lighted area. The later work has emphasized a reduction in the number of lamps used per unit area, with consequent reduction in the cost of installation and operation. The studies have also pointed toward procuring results of a more practical nature by experimentation with such features as the kind of light most attractive to the corn borer, improvements in trap structure, the necessary time of operation, lamp distribution, the position of the traps as to height above the corn, the contour of the land, and other factors which might affect the catches of corn borer moths.

Presented before the Rural Electric Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 7, 1939. The authors are, respectively, associate in entomology, associate in agricultural engineering, and assistant in agricultural engineering, Purdue University Agricultural Experiment Station. The research reported was conducted in cooperation with the Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.



RELATION OF CORN HEIGHT TO THE NUMBER OF MOTHS CAUGHT IN LIGHT TRAPS

There are several factors which appear to influence the number of moths captured at various traps, or to have a bearing on the flight of the corn borer adults to lights. The most important factors appear to be the height of the corn under or surrounding the traps, the distribution of the traps, the height of the traps above the corn, the position of the traps with regard to the prevailing winds, and the height of the traps with regard to the topography or contour of the lighted area. Such influences are not easily segregated into individual factors, since the moths have probably been influenced by a combination of factors.

DIRECTIONAL INFLUENCE OF WIND ON TRAP EFFECTIVENESS

It has been noted that those traps situated on the eastern side of the field have yielded the most adults, and those traps located on the northern end of the eastern row have been especially effective. This may be logically accounted for by the fact that the moths normally travel against the wind in their search for corn, and those traps located on the northeastern corner are the first to be encountered, since southwest winds prevail at the time of maximum moth activity. Of a total of 11,167 moths observed, 5,711 were taken in the eastern string of traps. This occurred in spite of the western series having had the advantage of additional height, due to soil surface contour. In the 1938 experiments, where corn heights and field contour were more nearly equal because of an almost level field with little soil variation, the eastern row of five lamps captured 2,005 moths, as compared to 1,644 in the second row, 1,265 in the third row, and 740 in the western row.

Possibly the greatest single factor determining the flight of moths to traps of equal light output is the height of the corn under or in the immediate vicinity of the traps. This has best been shown by a comparison of catches made during the flight of the second generation, which occurs chiefly during August when the influence of soil conditions on plant growth has had a better opportunity to assert itself. There appears to be an almost direct correlation between corn heights and moth catches, when other factors are about equal.

There is increasing evidence in the experimental work that the height of the traps, both above the corn and in relation to the contour of the field, has a bearing on the captures of corn borer moths. In our preliminary work, based upon our knowledge of the flight habits of the moths, the traps were raised as the height of the corn increased, so

that the traps were at all times suspended just above the level of the corn. In later work the traps were suspended from 11 to 12 ft above the ground at all times, with evidence that even greater heights would still further increase the catches or permit a reduction in the number of traps per unit area. Likewise, probably due to a greater dispersion of light, traps placed on the higher spots of the field, other things being equal, were more attractive than those placed in the low spots.

A problem which came in for early consideration in these studies was that of light trap distribution. In an earlier article[1] it was shown that even distribution of traps over the field was superior to a marginal plan of lighting. The marginal plan had, as an object, the screening of the moths from the field by providing a barrier of light through which they must pass in order to reach the corn, while the plan of even distribution, found to be the better method, aimed at capturing them within the field or preventing oviposition. The latter plan trapped 129 per cent more moths than the marginal plan (Table 1). Borer infestations and populations were higher in the marginally lighted area at the end of the season than in the area where the traps were evenly distributed.

TABLE 1. POSITION OF LIGHT TRAPS IN RELATION TO THE MARGINS OF THE FIELD AND THE NUMBER OF MOTHS CAPTURED

Trap No.	Position	No. of moths captured	Trap No.	Position	No. of moths captured
1	Inside	274	1	Margin	187
2	Inside	503	5	Margin	165
3	Inside	440	6	Margin	152
4	Inside	480	7	Margin	179
5	Inside	308	8	Margin	168
6	Inside	315	9	Margin	119
7	Inside	348	10	Margin	122
8	Inside	392			
9	Inside	352			
10	Inside	327			
2	Inside	263			
3	Inside	352			
4	Inside	298			
Average		358			156

Two blocks of corn were experimentally lighted in 1939. One was a ten-acre block of field corn, a part of a field of 17 acres, chosen because of its outstanding earliness, height, and vigor. Such conditions are conducive to the attraction of the maximum number of moths. Electrocutor traps equipped with 250-watt, 115-volt, mazda CX lamps were placed uniformly over the corn at the rate of one per acre.

The other block was of sweet corn, planted at a somewhat later date, which was thought to be particularly favorable for second-generation infestation. The four-acre field was lighted by four 100-watt, H4 lamps suspended uniformly over the corn at the rate of one per acre.

All lamps were operated at a height of from 10 to 11 ft throughout the active season of the corn borer adults and from dusk until dawn, a nightly average of approximately 7 hr. Due to the development of a second generation of the borer in Indiana during the past four years, the lamps were lighted continuously each night from June 16 to September 6, in order to follow the trend of second generation development and moth flight, although the number of moths captured during a period of two weeks between broods was negligible as a practical control measure.

[1]Ficht, G. A. and Hienton, T. E. Studies on the flight of European corn borer moths to light traps: A progress report. Jour. Econ. Ent., Vol. 32, No. 4, 1939.

THIS VIEW SHOWS A CORN FIELD IN THE PURDUE EXPERIMENTS IN WHICH ELECTRIC LIGHT TRAPS TO CONTROL EUROPEAN CORN BORER WERE PLACED UNIFORMLY OVER THE CORN AT THE RATE OF ONE PER ACRE

Table 2 shows that a considerable number of moths were taken in the traps in the field corn during the season, the greatest number being taken during the second-generation flight. A total of 2,974 were taken in the first flight as compared to 8,193 in the second, making a total of 11,167 for the season. The peak catch in one night during the first generation flight was 439 moths, and that of the second, 900 corn borer adults. The number of moths captured per trap was smaller in the sweet corn than in the dent corn, the average per trap being 304 and 1,116, respectively. This may not have been entirely due to the different light sources, as the sweet corn was later and shorter than most of the neighboring corn, while the field corn was the tallest in the locality.

TABLE 2. MOTHS CAPTURED BY TRAPS DURING 1939

Type of corn	Trap No.	No. in first brood	No. in second brood	Totals
Dent	1	286	986	1,272
	2	255	890	1,145
	3	276	717	993
	4	289	722	1,011
	5	244	791	1,035
	6	288	726	1,014
	7	608	703	1,311
	8	279	829	1,108
	9	236	779	1,015
	10	213	1,050	1,263
	Totals	2,974	8,193	11,167
Sweet	1	38	283	321
	2	57	241	298
	3	67	215	282
	4	79	237	316
	Totals	241	976	1,217

A question arises as to the practical significance that may be attached to the number of adult corn borers captured, and as to the probable reduction in numbers, due to their removal from the fields. The result could only be theoretically calculated in general figures. In the experiment with field corn, assuming that each female moth laid 500 eggs, and on the basis of a survival rate of 7.5 per cent of the eggs which resulted in full-grown larvae, as calculated from 14 midseason strains of hybrid corn which were comparable to the Iowa hybrid 939 used in these experiments, the infestation and population of the field would have surpassed that of the check areas used for comparison. Since the field was selected because of its earliness, height, and advanced stage of development as likely to receive the most eggs of any in the locality, this theoretical calculation would seem to be a conservative estimate of what the infestation and population might have been if no moths had been removed. It is not known, how-

ever, how far the moths were attracted to the lamps used and how many might have been removed from closely located unlighted fields.

Counts on the sex of the captured moths showed that of the 11,167 taken during the course of the experiment, 6,772, or 60.64 per cent, were females. As in previous experiments, the percentage of females was higher in the second generation flight than in the first. Of 4,067 moths taken during 1938, the first generation averaged 52.3 per cent females and the second 70.3 per cent, making an average of 65.5 per cent females. In 1939, the two broods averaged 55.55 and 71.72 per cent, respectively (Table 3).

TABLE 3. SEX OF MOTHS FROM TRAPS IN FIELD CORN DURING 1939

Generation	Total	No. of males	Per cent	No. of females	Per cent
First	2,974	1,322	44.45	1,652	55.55
Second	8,193	3,073	37.50	5,120	62.49

According to Stirrett[2] the reason for this phenomenon is that the male corn borer moths are attracted primarily by the females, while the female moths are attracted primarily to corn as an oviposition host, hence the moths captured in corn are predominantly females.

Practically all female moths taken at lights in our experiments have been gravid and never more than one per cent have spent themselves.

Infestations and populations in the experimental areas were greatly reduced, but were not eliminated, by lighting (Table 4). The areas used as checks for the field corn were the seven acres of unlighted area in the experimental field and three nearby unlighted fields of the same hybrid strain of corn which were planted on approximately the same date. It would be expected that the lamps had an effect of drawing moths from the unlighted block of the experimental field and that the infestations and populations in this block would be reduced as a result. Therefore, the other fields, located well beyond the immediate influence of the lights, are undoubtedly the more accurate checks.

TABLE 4. INFESTATIONS AND POPULATIONS IN LIGHTED FIELDS AS COMPARED TO CHECK AREAS

Field corn	Per cent of plants infested	No. of borers per 100 plants	Per cent population reduction in lighted areas
Lighted block	52.2	78.75	
Unlighted block, same field	80.0	234.40	66.40
Unlighted field, ¼ mile removed	89.0	320.40	75.42
Unlighted field, ¾ mile removed	79.0	308.60	74.48
Unlighted field, 1 mile removed	88.0	316.00	76.24
Sweet corn			
Lighted block	4.8	6.0	
Unlighted field, ¼ mile removed	71.0	101.5	94.09
Unlighted field, ½ mile removed	64.5	89.6	93.30

It would seem from the population figures relative to the lighted sweet-corn field, that the degree of control is out of proportion to the number of moths captured in the light traps when compared to the field corn. However, the sweet corn, both lighted and check areas, though not as attractive as an oviposition host as the field corn because of its reduced height, had a higher rate of larval survival because of the shorter required growing period and increased populations due to a lower rate of stand.

Populations in the lighted area were not evenly distributed, accumulations of borers being present under or in the vicinity of the lights. This may have been due to the increased height of the corn under the lights as a result of the enhanced growth resulting from the lighting. Improvements in the traps might also reduce or eliminate this feature of the infestation as moths have frequently been observed to circle the lights and in a blinded condition drop into the corn unharmed. Baffle plates, which would eliminate this condition, require further investigation.

The maximum nightly period of operation necessary to capture the moths would be 7 hr, although this period could be shortened by one hour per night without greatly influencing the catch from a practical point of view. The maximum flight occurred from dusk until 2:00 a.m., after which it dropped off rapidly. A temperature of below 60 F (degrees Fahrenheit) is not sufficient for flight and this temperature is frequently reached by 2:00 a.m.

The number of nights of operation required for the control of the borers of the first generation has been as follows: 1935, 27 days; 1936, 39 days; 1937, 28 days; 1938, 38 days; 1939, 32 days. The average number of days of required operation for the 5-yr period was 33. The number of nights of operation required to control the second generation for the past five years has been as follows: 1935, no operation; 1936, 12 days; 1937, 21 days; 1938, 43 days; 1939, 30 days. An average figure in this instance would be of no value, as the second generation has only developed into an important economic factor since 1936. The variation in the length of the period of moth flight and required light trap operation is dependent on weather conditions from year to year, the 1938 and 1939 seasons having the longest periods on record in Indiana. Favorable seasons for increase, however, will be those in which the climatic conditions favor the long life of the corn borer moths and where light traps will need to be used over the longer periods.

To sum up the probable required time of operation of lights for the control of the borer in each of the two generations, each light would need to be operated for 192 hr for the first brood and approximately 219 hr for the second generation. At a rate of 4 cents per kilowatt hour, the operation of one 250-watt lamp per acre would cost $1.92 for electric current for the control of the first generation and $2.19 for the second generation. As pointed out in a previous publication[1], the operation of light traps during the moth flight of both generations would not seem necessary for either field corn or sweet corn.

Preliminary laboratory observations seem to indicate that color is a much less important factor in attractiveness than light intensity, and that intensity and the size of the luminous area are the important considerations in determining the lamps to be used in the traps. Further studies on this subject are in progress.

Further observations on light traps as a control for the European corn borer indicate their possible practical application for use against this insect under certain circumstances. While they are not being recommended at the present time, the preliminary results indicate they may be of considerable economic value in protecting corn against severe losses. Sweet-corn growers producing both canning and market crops would be particularly benefited by such a method of control, should there be heavy infestations of the insect. The cost of operation is not excessive where crops of considerable economic value need protection.

[2]Stirrett, G. M. A field study of the flight, oviposition and establishment periods in the life cycle of the European corn borer, *Pyrausta nubilalis* Hbn., and the physical factors affecting them. Sci. Agr. Vol. 18, Nos. 7-12, 1938.

An Approach to the Farm Buildings Problem

By K. K. King

BECAUSE of the greater diversification of crops and greater mechanization of farms, public regulation of the storage and processing of farm products, and the very fact that farm population has increased in concentration, good buildings have become as essential as good land. Also, an ill-housed farm family is likely to be below par in health, and for that reason below par in available energy for physical output of farm labor. Concentration of farm families has produced public health problems in rural areas similar to those in urban areas, and ill-housed families more easily fall victims to the contagion of closely concentrated society.

For this reason, the Farm Security Administration has insisted that buildings susceptible of repair be put in first-class physical condition. When buildings are lacking or not susceptible to repair, adequate new ones are built.

Since the word "adequate" is more or less the shibboleth of any discussion on housing, as defined by the Farm Security Administration, it means a house which, for the climate in which it is built, is weather-tight and so constructed as to present to the weather a surface which is made of first-grade material. The interior of the house is designed with the minimum of space for each function of living considered adequate in the combined opinion of home economists, home management supervisors, and farm management supervisors of the Department of Agriculture. In setting forth their requirements they were asked to be extremely frugal, and we believe they succeeded in evolving the maximum amount of utility per dollar that present experience would permit. This statement is true of outbuildings as well as of houses.

Some of the minimum standards may be briefly stated as follows:

1 Windows and doors shall be in good repair and properly screened.

2 Sanitary privies or toilets designed to meet the accepted standards of the state health departments shall be provided.

3 The water supply shall be adequate for family and livestock needs. The water for domestic use shall be protected against contamination by drainage from privies, surface runoff, or otherwise.

4 Foundations must be adequate and sound, and floors in good condition.

5 Roofs must be water-tight and exterior walls protected by paint or other wood preservative.

6 Chimneys must be in such state of repair that they do not constitute fire hazards.

7 Sleeping quarters should be adequate to meet family needs; our general rule is a minimum of three bedrooms.

8 There should be adequate provision for storing food, clothing, utensils, tools, and produce.

9 There should be adequate shelter for poultry and livestock.

10 No attempt should be made to repair buildings that are in such condition that they should be demolished and replaced by new structures.

Using these standards and farm plans, for all the buildings which compose a farm plant, we have been able to erect new structures which are frugal and simple, but functionally adequate, within the abilities of a farm family to pay the interest and amortization on a one-family farm, with a few exceptions, throughout the United States.

One of the most significant measures of the value of farm buildings has been the experience in the Farm Security Administration with the program administered by them under the provisions of the Bankhead-Jones Farm Tenant Act. Under this Act families are selected by a local committee, with the assistance of employees of the Farm Security Administration, to obtain loans from the government with which to purchase and improve a one-family farm. It has been determined that it is to the advantage of the family as the debtor, and equally to the advantage of the government as the creditor, to get the buildings into physical shape as rapidly as possible, because not until these buildings have been put into physical condition to perform their function does the farmer get fully into his farm operation, and therefore fully into the earning power with which to liquidate his debt to the government and provide operating means for himself. If the buildings are not completed with all possible speed, some part of the farm operations on which his ability to pay was premised will not be carried out. This is an important index of the great value of adequate operating plant in the form of farm structures.

As a corollary to this, it has also been discovered that the timeliness of getting buildings into proper condition is often a major factor in preventing spoilage from improper storage and illness from improper shelter during bad weather, both in the farm family and among the livestock on the farm. It is for this reason that the Farm Security Administration makes a great effort to time its loans and its building program with the agricultural seasons for the purpose of providing the entire building plant at the time when it has its greatest utility.

Of course, it is only possible for most farmers to follow out the plan of providing adequate buildings all at one time to form a complete operating plant, when cheap long-term capital is available under the proper conditions. Conversely, however, when cheap long-term capital is available, as it is under the Bankhead-Jones Farm Tenant Act, there is no excuse for following any policy which permits the farmer to be dilatory in the construction of his buildings, because he will not get fully into his operation, and will not come into the income position on which the entire loan was based, until he has all his buildings. Therefore, when loans are made for buildings or repairs to buildings, the Farm Security Administration supervises their construction at the earliest possible date.

The Farm Security Administration cooperates with the extension service and other agencies, using in many cases plans developed by the other services, which have been found suitable for particular localities. The Administration is intended to serve a low-income group, to place such low-income families in a position to attain self-dependence and security, and to make a beginning in the reduction of farm tenancy.

Presented before the Farm Structures Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 6, 1939. The author is district engineer (District III), Farm Security Administration, U. S. Department of Agriculture.

A New Device for Laying Out Contour Lines

By L. H. Schoenleber
MEMBER A.S.A.E.

AN INSTRUMENT to facilitate the laying out of contour lines has been designed and developed at the soil and water conservation experiment station near Clarinda, Iowa. It is called a grade meter, is mounted rigidly on a tractor in front of the operator (Fig. 1), and indicates on what grade the tractor is operating or on what grade off a contour it may be operating. It operates mechanically and has proved sensitive and accurate.

The grade meter consists of a pendulum attached on a ball-bearing-mounted shaft which is connected to an indicator arm through a train of gears. The mechanism is so mounted on the tractor that the pendulum swings parallel with the direction of travel. As the pendulum swings, it turns the shaft and causes the indicator arm to move. The indicator moves over a scale arranged to show deviations from zero, and thus show the plus or minus grade of the land, so that the operator, in laying out contour lines, steers the tractor to read zero at all times.

The author is assistant agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture, stationed at soil and water conservation experiment station at Clarinda, Iowa.

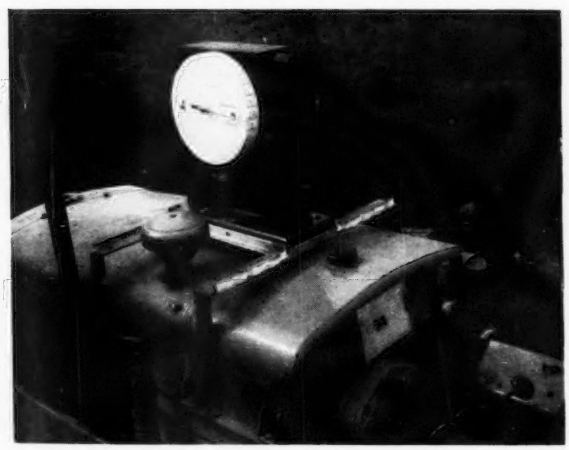


FIG. 1 GRADE METER MOUNTED ON A TRACTOR. THE INSTRUMENT WAS DEVELOPED AND PATENTED BY THE AUTHOR

Shocks or vibrations transmitted from the tractor would normally cause the pendulum to swing too freely and the dial indicator to make wide, irrelevant readings. This was overcome by submerging the pendulum in a vat of heavy transmission oil, and mounting strips of sheet metal in the form of plus signs on all four sides of the pendulum to furnish additional resistance.

In tests the grade meter was mounted on two different types of tractors and operated on different slopes and on land planted to different crops. Seven contour lines were run with a track type tractor and four with a wheel type tractor (Table 1). All contour lines were run with the tractor operating in low gear, except line 6, which was run with the tractor operating in second gear at a speed of approximately 2.6 mph. The best results were obtained when the tractor was driven in low gear and at approximately one-half throttle, as this allowed the operator to steer more easily on the contour. Contour lines were run on a bluegrass pasture, a disked oat field, listed cornland, clover with a seeding of oats, and on land having slopes of 6.9 to 18.0 per cent. Deviation from the average elevation of the lines run is shown in Figs. 2 and 3. The greatest deviation occurred when the tractor was operating in second gear; apparently the deviations were greater when the tractor was operated at high speeds on steep slopes. The average maximum grade for 100-ft distances exceeded 1 per cent on only three lines.

Observations show that contour lines laid out with a level often have sharp curves or bends caused by uneven slopes, waterways, or ground surfaces. When farming operations are performed on these lines, the sharp curves or bends are smoothed out, and deviations from the true contour result. Contour lines laid out with a grade meter mounted on a tractor automatically smooth out such bends (Figs. 4 and 5). In these tests the type of cover and condition of the land seemed to have little effect on the accuracy of the results obtained with both the track and wheel type tractors.

It is estimated that with a grade meter an average farmer can lay out 1½ mi of contour lines per hour. The

FIG. 2 (LEFT) CONTOUR LINES RUN WITH A NO. 22 CATERPILLAR TRACTOR. FIG. 3 (RIGHT) CONTOUR LINES RUN WITH A JOHN DEERE GENERAL-PURPOSE TRACTOR

simplicity, ease of operation, and convenience of this instrument may enable farmers to run contour lines during slack periods on the farm.

It is recognized that when most soil and water conservation methods are universally adopted, they will be applied and maintained by individual farmers. Hence any method that assists the farm operator to install recommended soil and water conservation practices is of inestimable value.

TABLE 1. CONTOUR LINES RUN WITH A GRADE METER

Line number	Length of line, ft	Kind of tractor used	Gear in which tractor was operated	Approximate speed of tractor, mph	Average slope of land, per cent	Elevation of lines*			Maximum grade for			Crop
						Average, ft	Maximum, ft	Minimum, ft	Greatest deviation from average, ft	50-ft distance, per cent	100-ft distance, per cent	
1	400	Caterpillar No. 22	Low	1.9	18.0	9.19	10.00	8.39	0.81	1.6	1.0	Bluegrass pasture
2	570	do	do	1.9	9.4	10.25	11.17	9.53	0.92	0.8	0.4	Listed corn
3	725	do	do	1.9	9.3	8.80	10.00	8.10	1.20	1.3	0.8	Oats, disked
4	250	do	do	1.9	8.9	9.88	10.78	9.27	0.90	1.5	0.6	Clover, with seeding of oats
5	250	do	do	1.9	6.9	9.15	10.15	8.40	1.00	2.0	1.2	Bluegrass pasture
6	250	do	High	2.6	17.8	7.60	10.12	6.18	2.52	3.3	2.5	do
7	330	do	Low	1.9	17.6	9.96	10.26	9.61	0.35	0.7	0.3	do
8	500	John Deere, general-purpose	do	2.3	7.4	9.39	10.43	8.62	1.04	1.3	1.0	do
9	1225	do	do	2.3	9.3	9.28	10.00	8.83	0.72	0.9	0.5	Oats and seeding of clover
10	280	do	do	2.3	17.7	9.56	10.04	9.00	0.56	0.7	0.5	Bluegrass pasture
11	360	do	do	2.3	17.8	7.50	10.00	6.11	2.50	2.3	1.9	do

*Elevations were taken every 10 ft along the lines.

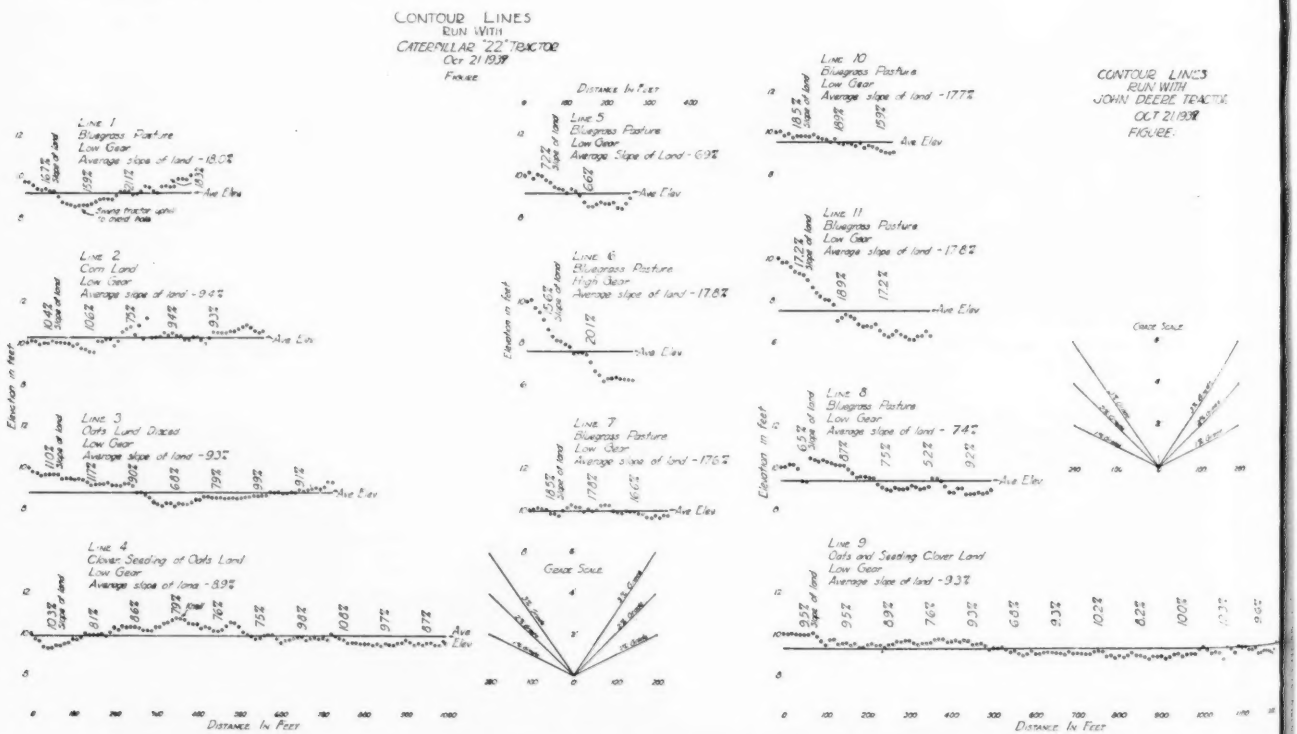


FIG. 4 (LEFT) CONTOUR LINES RUN WITH A NO. 22 CATERPILLAR TRACTOR. FIG. 5 (RIGHT) CONTOUR LINES RUN WITH A JOHN DEERE TRACTOR

Some Aspects of Mechanization in American Economy

By Harry G. Davis
MEMBER A.S.A.E.

IMPORTANT technological changes instituted by the engineering profession frequently set in motion certain evolutionary forces, the effects of which cannot be recognized for a long time, and, usually, when they are detected they have become so commonplace that it is almost impossible to appraise their true value. Such has been the case of mechanization.

For instance, when McCormick brought out the mechanical reaper a little more than a century ago, he set in motion the processes of farm mechanization which ultimately were to change the economy of the entire world and the sociological destiny of millions then unborn.

Now that a century has elapsed since that epochal day, and mechanization has been developed to the degree that practically every farm job can be done by a machine, we find agricultural mechanization so commonplace that it is almost impossible for us to appraise the real contribution it has made to national welfare.

The trouble is that so many people of this generation have become so accustomed to our mechanized way of doing things that they are unable to conceive conditions that existed before the advent of the machine. They accept mechanization as a mere matter of fact and never stop to consider the great changes that have been wrought by it, or that most of the things they hold near and dear are really the fruits of mechanization.

America, as we of this generation know it, is a mechanized nation. In almost every detail of our daily lives, we are brought face to face with some form of a machine, or, at least, with some machine-made product. But it was not always thus in America. When the founding forefathers came to build a new nation in the wilderness, there were no machines to help them.

THE BASIS OF MATERIAL WELFARE

How mechanization has changed the situation! But has it improved it? Are we better or worse off? In approaching this inquiry, it might be well for us to bear in mind the fundamental principle that man's material welfare is governed in part by the volume of goods, or the amount and quality of services, he is able to supply to his fellow men. That was the basis of John Smith's famous edict at Jamestown when he decreed that "he who would not work should not eat", and it has been a fundamental of man's material progress throughout the history of the world. The more goods, or the better service, a man can render to his fellow men, the greater are the material rewards he can collect for them.

It seems to me we can accept as true the statement that the main function of production machines is to increase the volume of goods an individual can produce. When men worked with the simple hand tools that were in use before the advent of production machinery, the volume of goods they could produce was greatly limited, and naturally the compensation they received for producing them was correspondingly small. It was not until men started to use machines to help them produce more goods that their material welfare began to expand.

Proof of this statement can be found in the history of our country, and particularly in the history of the past century. In that hundred years we have witnessed the major portion of the transition from hand to machine methods of producing most commodities. We have seen industrial wage rates—the material rewards of workers—increase from about 8 cents an hour in 1840 to more than six times that amount at the present time. We have seen the workingman's toil reduced by the machine and his hours of labor shortened. Coincident with all this, we have seen him emancipated from a state closely bordering on serfdom and elevated to a status which enables him to enjoy a standard of living, exceeding in its luxuries and opportunities that of princes in the premachine era.

MECHANIZATION AND INDUSTRIAL AMERICA

America, originally an agricultural nation, has been transformed by mechanization into an industrial country with nearly 80 per cent of its working population engaged in nonagricultural pursuits as compared to less than 20 per cent a century ago. Its manufacturing industry is said to date from the closing years of the eighteenth century, or from the invention of the cotton spinning machine by Samuel Slater in 1790, the first production machine in American industry of which we have any record.

It may sound strange to the man who has not studied the subject deeply, to hear anyone say that there has been a steady increase in factory employment in the face of the introduction of what commonly are called "labor-saving" machines, and he may want an explanation. The answer is simple. New industries and new occupations, together with a wider use of the products of older industries, explain the situation.

But it was not solely in the employment furnished by these new industries that total employment in the country increased in the face of expanding mechanization. Larger factory payrolls and larger incomes for other people have created a buying power which is being expended for goods and services which otherwise might not have been required.

It is not only through increased employment and larger earnings of factory workers that mechanization benefits American people. Through it we get more and better products at lower prices. Without our mechanized factories and our mass production methods, many of the things now in common use would be so high in price that few people could afford them.

Our modern standard of living—unequalled anywhere else in the entire world at any time in history—is the result of our mechanized American economy. Without our machines, we would have to revert to the living standards of our grandfathers and great-grandfathers. If we junked the spinning machine, it would require the equivalent of the entire working population of the whole United States laboring from dawn to dark, 365 days a year, to produce by

---

An abridgment of an address before the general engineering convocation, University of Nebraska, December 12, 1939. The author is director of research, Farm Equipment Institute.

methods in use prior to the introduction of Slater's machine, as much cloth as is annually made and mostly consumed in this country.

In the development of our mechanized American economy, there is nothing else which has played a more important part than have farm machines. In fact, it is extremely doubtful if our marvelous industrial development could have been accomplished had not agricultural mechanization proceeded simultaneously. With the country being launched on its way to becoming an industrial, rather than an agricultural nation, agriculture had several definite responsibilities to be fulfilled, as follows:

1 It had to produce the food and the raw clothing material required for the sustenance of those who entered industrial employment and ceased producing them for themselves.

2 It had to supply many of the raw materials, such as cotton, wool, hides and grain, for some of these new industries.

3 It had to release some of its own man power in order that these new industries might be manned.

INCREASED EFFECTIVENESS OF FARM WORK

Let us take a look at the situation as it existed in 1820, the first year for which we have Census Bureau data. In that year, 83.1 per cent of the total working population was engaged in agricultural pursuits and only 16.9 per cent was otherwise employed. In those days, unaided by machinery, it required about 57 hours of man labor to grow and harvest an acre of wheat yielding 20 bushels; 33 hours to produce an acre of 40-bushel corn, and 148 hours to produce an acre of cotton yielding 750 pounds of seed cotton. Had such excessive labor requirements in the production of farm crops continued, it is doubtful if the new industries which were being launched could ever have gotten under way. They would have failed for want of man power.

But agriculture, like manufacturing industries, turned to machines to increase the productive capacity of its workers. The reaper and the binder, and later the tractor and the combine, with the other machines used with them, brought the hours of labor required to grow an acre of wheat from 57 in 1830 to 8.8 in 1896 and on down to 3.3 in 1930. Other machines made comparable reductions in labor requirements for the production of other crops, and millions of people were then able to turn from agriculture and join the vast armies that were marching into nonagricultural pursuits, assured of a dependable supply of food and fiber for clothing from a mechanized agriculture.

I would like to have you get the thought that mechanization by farmers in this country has been a necessity, as well as a desire, and that there will have to be further mechanization to maintain a balance with the ever-increasing labor efficiency in manufacturing industries. No farmer who uses his labor inefficiently can expect to get an even exchange when he sells his products and buys factory-made products produced through the efficient use of labor. If he studies the problem deeply, he will come to the realization that he has spent several hours of his own labor to get the products of a single hour of labor of some factory worker. On the other hand, the farmer who uses labor efficiently through the use of modern machinery is able to exchange his products for those of other industries on a much more favorable basis.

Between 1900 and 1938, the population of the United States increased 70.8 per cent. Production of wheat in the 5-year period, 1934-38, increased 30.5 per cent over average production in the 5-year period, 1898-1902, and cotton production increased 24.9 per cent while corn production decreased 15.1 per cent. The average number of all cattle on farms in the later 5-year period increased 16.3 per cent, while the number of hogs on farms decreased 10.6 per cent. These figures, and all others I have been able to find, seem to demonstrate that there is no overproduction of agricultural products which should result in the accumulation of surpluses, and that those which do exist are due more to underconsumption of farm products and the loss of foreign markets than to the fact that some of these crops were produced by machine methods.

Now let us take a look at this thing called "technological unemployment" and see what part farm machinery may have had in creating it, if it really exists. I maintain that there is no unemployment in the United States today which has been caused by farm mechanization. In fact, there is a great deal of what might be called "technological *employment*" that is directly due to farm mechanization.

All the employment used, directly or indirectly, in the manufacture and distribution of farm equipment (which runs into the tens of thousands) sinks to mere insignificance when compared to the vast amount created in industries which resulted from transferring the processing of farm products, and the manufacturing of things made from them, from the home to the factory. More than one and one-half million people find regular employment in these factories and hundreds of thousands of others indirectly owe their jobs to them. Our grain elevators, flour mills, packing houses, canning factories, tanneries, boot and shoe factories, textile mills, and many other enterprises perform functions which were done on the farm in the premachine era. They all are the fruits of mechanization.

An important contribution of agricultural mechanization to economic and social welfare has been its effect upon the standard of living of American farmers. We older men, and you younger ones who are familiar with American literature, can easily construct a picture of farm life in the premechanized era. It is not a pretty picture. Contrast that picture with the up-to-date farm homes to be found throughout the country now that we have passed into the age of mechanical power in agriculture. Such homes have more comforts and convenience than the richest man in the world could have had a century ago because these things, now so commonplace, were not obtainable then. They are the fruits of the technological forces set in motion by the engineering profession.

FUTURE OPPORTUNITIES IN MECHANIZATION

The future holds an intriguing challenge to the young men now being trained in the science of engineering in this and other technical schools. It is a challenge to take up the work of your predecessors and to carry on. A challenge to improve the present machinery of agriculture and industry; to cooperate in the work being done to find new uses for existing surpluses and waste materials; to seek new applications in the use of electricity for the service of mankind; to learn more about the hidden forces of nature, and perhaps open undreamed of possibilities for human weal and happiness; in short, a challenge to do a thousand things which, in our present limited scope of human knowledge, no man can suggest.

You have the same native capabilities of your predecessors plus a better technical training. You have a wider perspective of the needs of mankind and a broader foundation upon which to build. Moreover, you have a more receptive public awaiting your accomplishments. The future of your country and of modern civilization depends largely upon the exploration of new horizons and the development of new frontiers which can be accomplished only through technological progress to be instigated by the engineering profession.

Transport Wheels for Agricultural Machines

V. Effect of Wheel Arrangement on Rolling Resistance

By Eugene G. McKibben and J. Brownlee Davidson

FELLOW A.S.A.E. CHARTER A.S.A.E.

SUMMARY

1 Data are given for the rolling resistance of single, dual, and tandem arrangements of 6.00-16-in implement tires when operated at loads of 500 and 1000 lb per tire on bluegrass, tilled loam, and loose sand.

2 The rolling resistance for the dual arrangement did not differ greatly from that of a single tire.

3 Of the three dual spacings (8, 12, and 16-in) studied, the intermediate (12-in) spacing appears to have a slight advantage.

4 The tandem arrangement materially reduced the rolling resistance, particularly at the heavier load on loose sand, where the reduction was 34 per cent.

5 Repeated trials of single wheels run in the same track confirm the results obtained with the tandem arrangement and emphasize the gain in power economy to be obtained by arranging for the wheels on field equipment to track whenever practicable.

IN ORDER to study the effect of wheel arrangements on rolling resistance the mountings shown in Fig. 1 were used with the testing machine described in Fig. 6 of the second article of this series[1]. With this equipment tests were made on bluegrass pasture, tilled loam, and loose sand at loads of 500 and 1000 lb per wheel. The data thus obtained are given in Table 1 and shown graphically in Fig. 2.

Dual Mounting. The dual arrangement was tested at three spacings, 8, 12, and 16 in, respectively, from center to center. For the field conditions studied the rolling resistance for these dual arrangements did not differ greatly from that of the single mounting, although the 8-in spacing appeared to have an advantage on the tilled loam, and the 12-in spacing an advantage on loose sand. On the other hand, all three dual arrangements appeared to have an appreciable disadvantage at the 500-lb load per tire on the bluegrass pasture.

Considering all three conditions studied, the 12-in spacing seemed to be the best. The evidence is not very conclusive, however, and it is probable that convenience and economy of design and construction should be given more importance than rolling resistance in determining the spacing of dual tires.

Tandem Arrangement. The tandem arrangement reduced the rolling resistance in all cases, except for the 500-lb load per tire on the relatively firm bluegrass pasture. The advantage of this arrangement was particularly important in the case of the heavier load on loose sand, where the reduction in rolling resistance was 34 per cent.

Thus, from the standpoint of reduced rolling resistance and resulting power economy, there is considerable gain in designing field machines so that transport wheels will "track" wherever this is possible. Further, where a rubber-tired tractor is used an additional reduction in rolling resistance can be expected from arranging the wheels of drawn machines so that they will follow in the tracks of the tractor's wheels.

TABLE 1. ROLLING RESISTANCE[a] OF THREE ARRANGEMENTS OF 6.00-16-IN, FOUR-PLY IMPLEMENT TIRES AT TWO LOADS ON THREE FIELD CONDITIONS

Tire arrangement	Load, lb	Field condition[b] B-bluegrass Lb	Per cent	C-tilled loam Lb	Per cent	D-loose sand Lb	Per cent
Single	500[c]	28	100	150	100	143	100
Dual 8 in center	"	36	129	144	96	135	94
12 in "	"	34	121	145	97	136	95
16 in "	"	34	121	152	101	142	99
Tandem	"	29	104	111	74	101	71
Single	1000[d]	60	100	319	100	338	100
Dual 8 in center	"	61	102	278	87	342	101
12 in "	"	59	98	290	91	308	91
16 in "	"	61	102	305	96	313	93
Tandem	"	57	95	223	70	223	66

[a] Each value is the mean of three nonconsecutive 50-ft, replications; the pooled standard errors of these means are 2.3, 2.4, and 10.3 lb, respectively, for bluegrass, tilled loam, and loose sand.

[b] Soil conditions are described in detail in Tables 1 and 2 and by Figs. 2 to 5 of Part II, Rolling resistance of individual wheels, AGRICULTURAL ENGINEERING, 20: 469-473. December 1939.

[c] Load per wheel. Inflation pressure 16 lb per sq in.

[d] Load per wheel. Inflation pressure 20 lb per sq in.

Repeated Trials in Same Track. To obtain additional information on the value of having transport wheels follow in the same track, a number of sets of tests were made in which trials were repeated in the same track. The rolling resistance data thus obtained are given in Table 2 and

Journal Paper No. J-726 of the Iowa Agricultural Experiment Station. Project No. 576, in cooperation with the American Society of Agricultural Engineers. Articles I to IV of this series appeared consecutively in AGRICULTURAL ENGINEERING for November 1939 to February 1940, inclusive.

The authors are, respectively, associate professor of agricultural engineering, and professor and head of the department of agricultural engineering, Iowa State College.

[1] McKibben, Eugene G. and Davidson, J. Brownlee. Transport Wheels for Agricultural Machines: II. Rolling Resistance of Individual Wheels. AGRICULTURAL ENGINEERING 20: 469-473. December 1939.

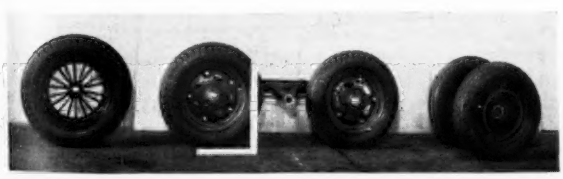


FIG. 1 SINGLE, TANDEM, AND DUAL ARRANGEMENT OF 6.00-16 TIRES USED TO OBTAIN DATA GIVEN IN TABLE 1

shown graphically in Fig. 3.

The reduction in rolling resistance from the first to the fourth trial on loose sand, 338 to 79 lb, respectively, amounts to 77 per cent. The data for soils L and M in Table 2 indicate the probability that on a soft loose soil tandem arrangement is more effective for pneumatic tires than for steel wheels, but that on a firmer soil the reverse may be true.

It should also be noted that the average of the first and second trials for each soil checks well with the values for the tandem arrangement given in Table 1.

Agronomic Effects. Unfortunately there is no conclusive evidence as to which arrangement of wheels would be most desirable from the standpoint of relative effects on the productivity of the soil. This problem is important but very difficult and its solution is beyond the resources of the present study.

TABLE 2. ROLLING RESISTANCE[a] OF TRIALS REPEATED IN THE SAME TRACK

Wheel	Pressure, lb	Load, lb	Trial number	Field condition: B-bluegrass[b] Lb	B Percent	C-tilled loam[b] Lb	C Percent	D-loose sand[b] Lb	D Percent
6.00-16	16	500	1	28	100	150	100	143	100
			2	28	100	78	52	66	46
			3	26	93	66	44	53	37
			4	25	89	54	36	51	36
	20	1000	1	60	100	319	100	338	100
			2	56	93	152	48	122	36
			3	53	88	107	34	91	27
			4	55	92	91	29	79	23
				L-soybean stubble[c]		M-cloddy loam[d]			
			1	122	100	248	100		
			2	114	93	124	50		
6x28	Steel	1000	1	185	100	314	100		
			2	143	77	202	64		
				N-tilled loam[e]					
4x36	Steel	600	1	108	100				
			2	79	73				
			3	56	52				
			4	52	48				
		1200	1	245	100				
			2	174	71				
			3	140	57				
			4	131	53				
				O-meadow[f]					
2.5x36	Steel	500	1	62	100				
			2	59	95				
			3	52	84				
			4	50	81				

[a]Each set of values given for the 6.00-16 tire and the 6x28-in steel wheel are the means of three 50-ft replications; the pooled standard errors of these means for the two wheels are 2.5 and 6.6 lb, respectively. The values for the 4x36 and 2.5x36-in wheels represent 100-ft individual trials.

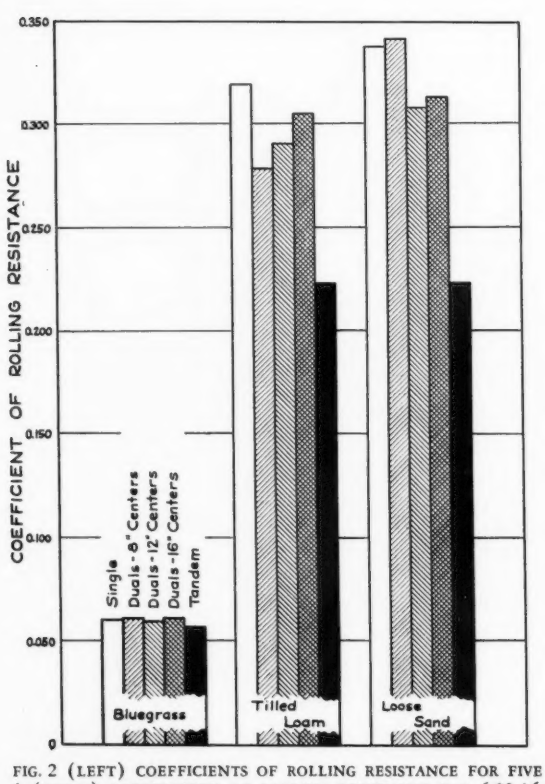
[b]Described in detail in Tables 1 and 2 and by Figs. 2 to 5 of part II, Rolling resistance of individual wheels. AGRICULTURAL ENGINEERING, 20: 469-473. December 1939.

[c]Soybean field after harvesting with combine. Trials were run at forty-five degrees to direction of cultivation and harvesting. Soil type, Clarion loam; weight and moisture content on dry basis, 75 lb per cu ft and 18 per cent, respectively; Iowa and Stone penetrometer readings, 1.8 and 4.7 in, respectively.

[d]Rough plowed oat stubble. Soil type, Clarion loam; weight and moisture content on dry basis, 67 lb per cu ft and 20 per cent, respectively; Iowa and Stone penetrometer readings, 6.0 and 9.3, respectively.

[e]Webster loam plowed 8 in deep, double-disked, and spike-tooth harrowed; weight and moisture content on dry basis, 61 lb per cu ft and 12 per cent, respectively.

[f]Timothy-clover meadow (one ton per acre). Soil type, Webster loam; weight and moisture content on dry basis, 67 lb and 24 per cent, respectively.



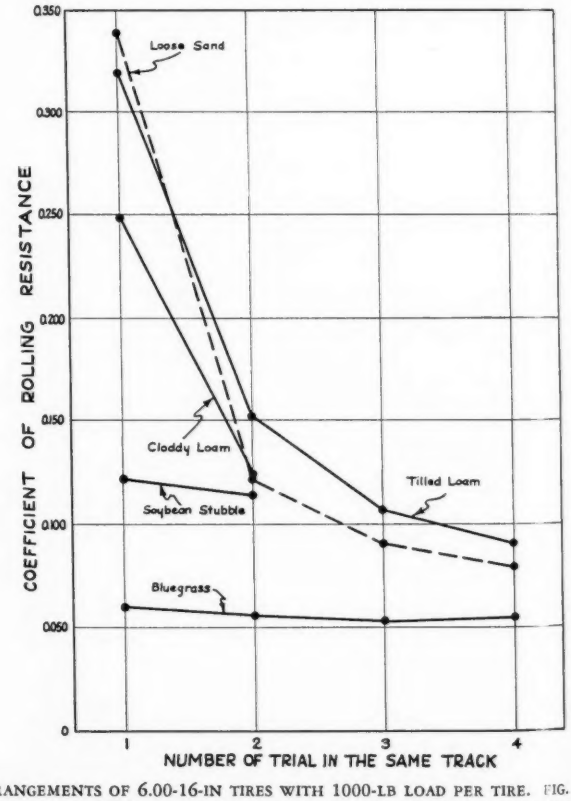


FIG. 2 (LEFT) COEFFICIENTS OF ROLLING RESISTANCE FOR FIVE ARRANGEMENTS OF 6.00-16-IN TIRES WITH 1000-LB LOAD PER TIRE. FIG. 3 (RIGHT) COEFFICIENTS OF ROLLING RESISTANCE FOR 6.00-16-IN TIRES WITH 1000-LB LOAD AND TRIALS REPEATED IN THE SAME TRACK

Progress Toward a Standard Tractor Fuel

THE Committee on Tractor Fuels proposed a specification for tractor fuel of the distillate or fuel oil class, at the fall meeting of the American Society of Agricultural Engineers, in Chicago, December 1938. It was published in AGRICULTURAL ENGINEERING for April, 1939 (Vol. 20, No. 4). The objects of making the proposal at that time were (1) to bring out discussion and criticism from the membership that would help the Committee in formulating a specification that would be as nearly satisfactory as possible for all concerned, and (2) to provide a basis on which to begin cooperation with other organizations which had invited cooperation on the problem.

The values of the proposed specification were as follows:

NAME: *No. 1 Tractor distillate*

OCTANE NUMBER: *30 minimum*

DISTILLATION: *Minimum*:
5 per cent point not lower than 325 F
95 per cent point not lower than 464 F
Maximum:
10 per cent point not higher than 400 F
25 per cent point not higher than 420 F
95 per cent point not higher than 515 F
End point not higher than 540 F.

Recognition and consideration of the following facts should be made in analyzing the problem:

1 Several oil companies make and sell a tractor fuel which meets all the requirements specified, but the practice is not common.

2 Little value will result from the adoption of a standard unless the tractor and engine manufacturers are willing to cooperate in its use and publication.

3 Much could be gained in an educational way if tractor engine manufacturers would publish a satisfactory distillate specification in their instruction books and literature.

4 The tractor manufacturers specify the quality of distillate on which their tractors are to be tested and rated at the University of Nebraska, and published results of tests indicate that all have specified an octane number higher than the minimum proposed.

5 Regardless of inherent advantages or disadvantages, the importance of the heavy fuels cannot be ignored at present, since thirteen states do not refund the agricultural gasoline tax, which places the gasoline-burning tractor at an economic disadvantage in those states and favors the low-grade fuel engine.

6 No attempt to force any fuel producer to meet any standard is contemplated.

7 Other societies have indicated a desire to turn the problem over to the American Society of Agricultural Engineers to solve if any solution is desired.

The Committee has made specific requests to several individuals in the oil and tractor industries for comments and criticism of the proposed specification. Replies have been received from eight engineers in the engineering departments of tractor and engine companies and from twelve representatives of oil companies. To indicate the attitude of the two industries concerned and to facilitate study of the problem, the pertinent remarks from each report are quoted here. Replies received from the tractor and engine industry will be considered first. Of the eight replies from this industry, six can be credited as being in favor of the general program, although they did not concur on all points; two were opposed. Following are statements quoted from these replies:

"..... by providing standardized fuels, which means writing of specifications which must be met, can lead only to higher prices which the consumer has to pay. ..... our position is one of being unfavorable to the program."

"Regarding the octane value of 30 as recommended in the proposed specification, personally, I am inclined to believe that this is a little on the low side, and I would prefer to see the octane value placed at a minimum of 35. ..... If other tractor manufacturers are in agreement with 30-octane value as being satisfactory, this company would not hesitate to go along with them in this respect."

"..... We should have better than 30-octane rating if we are to obtain best results from current engine designs ..... However, our desire for better than 30-octane fuel does recognize that there should be no penalty of higher price, as we are equally interested in a cheap fuel."

"..... large majority of our tractors go out equipped with high compression ..... therefore we do not worry much about low-grade fuel, except in states where gasoline tax is high. ..... we recommend fuel with end point not over 550 F, and 500 F if possible ..... prefer an octane of 30 or above ..... are able to get this almost any place. ..... doubt success of getting fuel much better without having the price too high."

"..... believe that you have done considerable work along this line and would be glad to follow your recommendations."

"..... would suggest that the octane number be raised to at least 35 minimum. ..... it would seem wise to consider adding something to the specification covering sulphur and gum."

"..... only reason for use of low-grade fuels is low price. ..... I would hesitate to recommend doing anything that could alter the price of such fuels. ..... The matter appears to me to be a question of making engines to fit the fuels rather than making the fuels fit existing engines."

Twelve replies were received from representatives of oil companies, eleven of which might be considered favorable and one unfavorable to the program of the Committee. Many of those which indicated a favorable attitude toward the activities of the Committee had objections to or suggested changes in certain points in the proposed specification. The following summary of remarks covers generally the attitude of the oil company representatives:

"..... The name No. 1 tractor fuel seems to have been more or less adopted in this area. However, there seems to be no reason why the name selected by your committee is not entirely appropriate."

Report of the A.S.A.E. Committee on Tractor Fuels—E. L. Barger (chairman), C. E. Frudden, C. N. Hinkle, C. L. Zink, and J. F. Goss. Presented before the Power and Machinery Division at the annual meeting of the American Society of Agricultural Engineers, at St. Paul, Minn., June 20, 1939.

"..... As far as your octane number of 30 minimum is concerned, I feel that you are perfectly sound."

"..... At least from the standpoint of octane number, you are not at all unreasonable and obviously most western kerosene distillates will comply with this requirement."

"..... As far as your octane number is concerned, we feel that the limit specified is entirely satisfactory."

"..... We do not believe that an octane of 30 minimum is essential or desirable because there is a question whether many refiners could consistently meet such a specification. It would also mean an increase in price because of the added manufacturing costs brought about by more rigid control in processing to insure a minimum octane of 30."

"..... We wish to advise that we feel a minimum of 30 octane is too high. A very good grade of tractor fuel can be produced from mid-continent crude oil, but the octane number will be well below 30. ..... However, we do produce tractor fuels of 40 octane to be used in special cases. It is our opinion and experience that if a high octane value is specified for tractor fuels, you are unduly penalizing the farmer, for as the octane value rises, the price rises in proportion."

"..... Incorporation of a proper octane number in the specification offers the most serious problem. In many instances of refinery processing, it is not a simple matter to obtain a 30-minimum octane number with a distillation range such as you have proposed. In other instances the refiner, due to an advantageous position relative to charging stock and processing equipment, can quite easily process a 30-octane number and even higher. Generally, however, if such a specification were adopted, rearrangement of processing would have to be resorted to in many cases in order to accomplish the purpose. This would no doubt entail additional processing costs, and it is reasonable to assume that the burden would be passed on to the consumer. On the other hand, however, I am of the opinion that at least 30 minimum octane should be incorporated in the specification rather than delete this item entirely. Otherwise the effectiveness of the proposed specification would largely be lost. I personally feel that the inclusion of a proper and effective octane number would be better than to leave it out."

"..... We would also like to suggest that the requirement of 30-octane number minimum is of questionable value as the C.F.R. engine is suitable only for rating fuels of the gasoline type. It is, of course, possible to obtain a calculated knock rating on stove oil by dilution of gasoline, but we question such results."

"..... As far as your distillation points are concerned, I feel that you are perfectly sound."

"..... From the standpoint of distillation range, you are not at all unreasonable."

"..... As far as your distillation requirements are concerned, we feel that the limits are entirely satisfactory."

"..... In reviewing the distillation characteristics of this tentative specification, it appears that the volatility set for 5 per cent at 325 F is well established, since it serves to control an excess of light ends frequently incorporated in tractor fuel. ..... we feel that the end point of 540 is likewise well established inasmuch as too heavy ends cannot be utilized in some tractor units. Your intermediate fractions, both minimum and maximum, should be entirely adequate for satisfactory performance."

"..... The present A.S.T.M. specification for No. 1 fuel oil calls for a 10 per cent not over 410, and an end point of not over 560, with the provision that this latter value may be increased to 590 when the oil is to be used in certain types of burners. Your Committee's proposed specifications call for a maximum 10 per cent of not over 400, and an end point of not over 540. It is thus seen that there would be two sets of specifications in existence which differ only slightly in their requirements, and in our experience the No. 1 A.S.T.M. fuel oil would give us as satisfactory results as your Committee's proposed specification."

"..... There does not seem to be anything very difficult in the manufacture of a tractor distillate of the character laid down by your committee. There may, however, be difficulties in the way of distribution of such a fuel. Extra grades always add to the distribution costs. It is for this reason that every fuel manufacturer likes to see specifications adopted which are as close as possible to the common grades of fuels which they already make."

"..... Our No. 1 tractor fuel meets this specification in every respect, and we feel that there is no requirement which would be difficult for the average refiner to meet. Adoption of a standard tractor fuel seems to us to be the logical procedure, and we are in hearty accord with such a movement."

"..... We do not make a tractor fuel meeting the specifications you have set up. We feel that you are working in the proper direction and that your specification is good as far as it goes. We would suggest that you include a minimum flash specification also."

"..... We would suggest that the American Society of Agricultural Engineers recommend the use of a tractor fuel complying with A.S.T.M. specifications for No. 1 fuel oil rather than attempt to set up so nearly similar specifications."

"..... We are quite sure that all the oil companies would heartily approve a uniform specification for fuel which would be satisfactory for all states in this territory. ..... Our automotive engineers have given careful consideration to the proposed specifications and are agreed that sulphur and gum are important enough to be included in a tractor fuel specification. However, placing a limit on the permissible amount of gum would mean that a highly cracked fuel would not be acceptable and this would mean that the octane number of the fuel would be lowered because of the elimination of the cracked product."

"In general, we feel that your proposed specification should not be published as a specification, but it should be called a classification in line with the practice of the A.S.T.M., S.A.E., and similar bodies. The reason for this is that the specification as given is not all inclusive, and it might be possible for a fuel to meet your requirements but still be unsuitable because of high sulphur, gum, and other unsatisfactory characteristics. In other words, this proposed specification should not be considered as complete and suitable for a purchase specification."

"..... Generally speaking, we have found the opinion of tractor manufacturers rather divided on the question of supplying fuels more volatile than your proposed specifications. There does seem to be, however, a definite preference on the part of the tractor user for the more volatile fuels, and the most salable tractor fuel today is the most volatile product which will not come within the particular state's definition of gasoline for tax purposes. We believe the American Society of Agricultural Engineers could render a definite service by working towards the unification of states' definitions for gasoline which, in the end, would control tractor fuel specifications."

An Analysis of Degree and Length of Slope Data as Applied to Terracing

By Austin W. Zingg

APPLICATION of a developed rational equation for soil loss as affected by degree and length of land slope will be made to the problem of terrace spacing and terrace effectiveness in an attempt to clarify a few of the factors involved in this mechanical control measure.

The rational equation used in this treatise was secured from data not designed for purposes of the study, and refinement will undoubtedly be possible. The equation furthermore does not represent absolute values for any given condition but is merely an average of available data on the subject.

The numerous details involved in the analysis of data, and in the experiments from which the equation was developed, are contained in the author's first article, entitled "Degree and Length of Land Slope as it Affects Soil Loss in Runoff", which appeared in the previous issue of AGRICULTURAL ENGINEERING (February 1940).

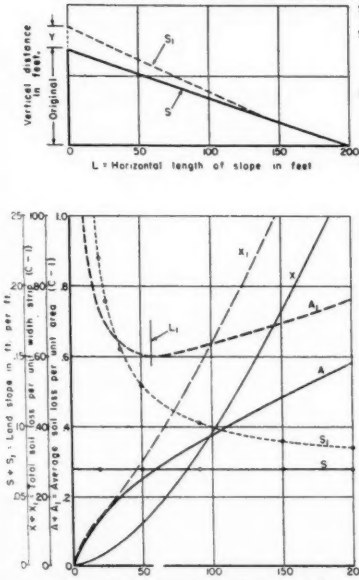
DEFINITION OF SYMBOLS USED

S = Degree of land slope, in feet per foot.
S_1 = Degree of land slope, in feet per foot, after a vertical distance Y has been added to the original slope.
L = Horizontal length of slope, in feet.
L_1 = Horizontal length of slope in feet at which a minimum value of average soil loss per unit area from a unit width strip occurs from S_1.
L_2 = Horizontal terrace spacing in feet for the minimum average soil loss per unit area from the interterraced area.
X = Total soil loss from a land slope of unit width.
X_1 = Total soil loss from a land slope of unit width after a vertical distance Y has been added to the original slope.
X_0 = Total soil loss to the terrace channel from a unit width strip above the first terrace placed on a slope and the front slope of the terrace ridge.
X_t = Total soil loss to the terrace channel from a unit width strip from the interterraced area and the front slope of the terrace ridge.
A = Average soil loss per unit area from a land slope of unit width.
A_1 = Average soil loss per unit area from a land slope of unit width after a vertical distance Y has been added to the original slope.
C = A constant of variation.
m = Exponent of degree of land slope
n = Exponent of horizontal length of land slope.
Y = Vertical distance in feet added to the original slope by application of a terrace.
b = Width of bottom of terrace channel, in feet.
t = Width of terrace ridge top, in feet.
s = Front slope of terrace berm, in feet per foot.

Presented before the Soil and Water Conservation Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 8, 1939. The author is assistant agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture, stationed at the Bethany (Mo.) soil conservation experiment station. The second of two articles by the author.

Figure 1

EFFECT ON SLOPE, TOTAL SOIL LOSS PER UNIT WIDTH STRIP, AND AVERAGE SOIL LOSS PER UNIT AREA FROM A UNIT WIDTH STRIP, BY ADDING A VERTICAL DISTANCE TO THE ORIGINAL SLOPE AND VARYING THE HORIZONTAL LENGTH OF SLOPE. SOIL LOSS UNITS ARE RELATIVE AND NOT ABSOLUTE.



S = Slope in ft. per ft.

S_1 = Slope after vertical distance is increased by Y. $= \frac{SL + Y}{L}$

X = Total soil loss per unit width strip as affected by degree and horizontal length of slope. $= CS^m L^n$.

X_1 = Total soil loss per unit width strip after vertical distance of slope is increased by Y. $= CS_1^m L^n$

A = Average soil loss per unit area from unit width strip as affected by degree and horizontal length of slope. $= CS^m L^{n-1}$

A_1 = Average soil loss per unit area from unit width strip, as affected by degree and horizontal length of slope, after vertical distance of slope is increased by Y. $= CS_1^m L^{n-1}$

L_1 = Horizontal distance at which a minimum value of A_1 occurs. $= \frac{my}{n-1} - Y$

Plotted values are for: S = 07, Y = 3 feet, C = a constant = 1.0, m = 1.4, n = 1.6

Figure 2

DERIVATION OF A THEORETICAL EQUATION FOR TERRACE SPACING

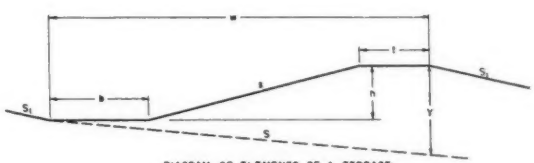


DIAGRAM OF ELEMENTS OF A TERRACE

b = Width of bottom of channel in feet.
t = Width of ridge top in feet.
s = Front slope of terrace berm in ft. per ft.
h = Vertical height of terrace in feet.
S = Original land slope in ft. per ft.
w = Horizontal width of bottom of channel, ridge top, and front slope of terrace berm.
$= b + t + \frac{h}{s}$

Y = Vertical distance added to the original slope by application of terrace.
$= h + s\left(b + t + \frac{h}{s}\right)$

S_1 = New land slope resulting from application of terrace.
A_1 = Average soil loss per unit area from S_1.
L_1 = Horizontal distance at which a minimum value of A_1 occurs from inter-terraced spacing on S_1.
$= \frac{my}{n-1} - Y$
S

L_2 = Horizontal terrace spacing for minimum average soil loss from the inter-terraced areas.
$= L_1 + w$.

By expressing L_1 and w in terms of b, t, s, h, S, m, and n;

$$L_2 = \frac{1}{S}\left(\frac{m}{n-1} - 1\right)\left[h + S\left(b + t + \frac{h}{s}\right)\right] + \left(b + t + \frac{h}{s}\right).$$

V. I. = Vertical terrace interval $= (L_2)(S)$.

$$\text{V. I.} = \left(\frac{m}{n-1} - 1\right)\left[h + S\left(b + t + \frac{h}{s}\right)\right] + S\left(b + t + \frac{h}{s}\right).$$

h = Height of terrace, in feet.
w = Horizontal width of bottom of terrace channel, ridge top, and front slope of terrace berm, in feet.
V.I. = Vertical interval between terraces, in feet.

TERRACE SPACING

In terracing a hillside the slope of the land between terraces is increased and the original total horizontal length of slope is decreased to the horizontal length resulting from the applied terrace spacing. It is probable that the desired terrace spacing for a particular soil type is in some manner related to these changes in degree and length of slope. Present terrace design experiments do not enable us to measure the total soil moved to the terrace channel, which, from a utilitarian standpoint, should in part be considered soil loss. The amount of soil measured in runoff at the end of the terrace is probably a small part of the total moved into the terrace channel. Terrace channels of approximately equal cross section are common to a series of spacing terraces. The amount of soil and water being carried by the channels is tremendously different due to the difference in size of areas drained. Variation of the stage of water in the terrace channels consequently results in different velocities of flow. Since the soil transporting power is proportional to the velocity of the water, unequal forces move soil from the several terrace channels within an experiment. It is, therefore, improbable that the amount of soil transported to the measuring device is directly proportional to the amount moved into the various terrace channels.

The rational equation developed in the analysis of data published in the author's first article will be used to study terrace spacing from the standpoint of soil loss to the terrace channel. The equation used is

$$X = CS^{m}L^{n}$$

or total soil loss from an area of unit width is equal to a constant of variation times the product of the degree of slope to a power and the horizontal length of the slope to a power. This equation is also used in the form

$$A = CS^{m}L^{n-1}$$

to express average soil loss per unit area from an area of unit width. Values of $m = 1.4$ and $n = 1.6$ are believed to be close to those which may be secured as yearly averages of field conditions and will be used for illustrative purposes.

To apply the equation it is necessary to make the following assumptions:

1 The profile of the interterraced area from the top of the terrace ridge above to the channel of the terrace below is a straight line.

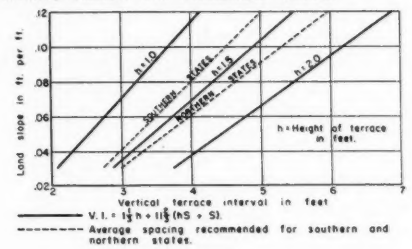
2 The soil is uniform over the entire terraced interval.

The above conditions would not apply to newly constructed terraces. They have, however, been approximated on relatively old terraced fields on research field stations of the U. S. Soil Conservation Service, where plowing has been accomplished with a two-way plow. The furrow slice in this instance has been turned uphill, opposite to the direction of the slope.

A condition analogous to that produced by terracing a slope is shown in Fig. 1. The sketch at the top of the figure represents a land slope having no drainage from above. On this slope S, relative values of total soil loss X and average soil loss per unit area A are graphed on the lower part of the figure for variations of the horizontal length of slope L. When a vertical distance Y is added to the original slope S, an increased slope S_1 results. Relative values of total soil loss X_1 and the average soil loss per unit area A_1 occurring from this increased slope S_1 are likewise graphed for variations of the horizontal length of slope L. Plotted values are for $S = 0.07$ ft per ft, $Y = 3$ ft, C, a constant of variation $= 1$, $m = 1.4$, and $n = 1.6$.

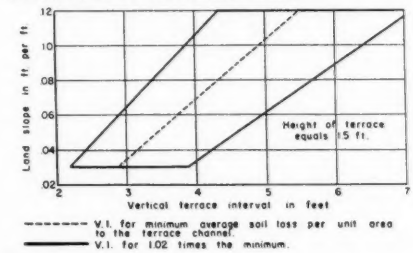
Figure 3

TERRACE SPACING DERIVED FROM THEORETICAL EQUATION FOR MINIMUM AVERAGE SOIL LOSS PER UNIT AREA TO THE TERRACE CHANNEL, COMPARED WITH RECOMMENDED SPACINGS.



V.I. = $1\frac{1}{2}h + 11\frac{1}{2}(hS + S)$.
Average spacing recommended for southern and northern states.

RANGE OF TERRACE SPACING WHICH WILL PERMIT A TWO PERCENT VARIATION FROM THE MINIMUM AVERAGE SOIL LOSS PER UNIT AREA TO THE TERRACE CHANNEL.



V.I. for minimum average soil loss per unit area to the terrace channel.
V.I. for 1.02 times the minimum.

It is noted that the average soil loss per unit area A_1 from the increased slope S_1 has a minimum value for a horizontal length of 57 ft. Without regard to specific values of Y, m, and n, this distance may be determined as follows for the condition $C = 1$:

$$A_1 = S_1^{m}L^{n-1}$$

$$\text{Since } S_1 = (SL + Y)/L$$

$$\text{by substitution } A_1 = \left(\frac{SL + Y}{L}\right)^{m} L^{n-1}$$

taking the derivitive of A_1 with respect to L.

$$\frac{dA_1}{dL} = \left[\left(\frac{SL + Y}{L}\right)^{m-1} L^{n-3}\right]\left[(SL + Y)\ (n-1) - mY\right]$$

Placing the derivative equal to zero and solving for the value of L for which A_1 is a minimum, which will be designated as L_1,

$$(SL_1 + Y)\ (n-1) - mY = 0$$

$$\text{and } L_1 = \frac{\frac{mY}{n-1} - Y}{S}$$

The theory of terrace spacing evolved is as follows:

When terraces of a given dimension are placed on a given slope, there is a length of interterraced spacing which will produce a minimum average soil loss per unit area from the interterraced area to the terrace channel.

By evaluating the vertical distance Y added to the original slope in terms of the more common dimensional elements of the terrace to be applied to the slope, it is possible to derive a theoretical equation for horizontal distance of terrace spacing or for the vertical interval to be used between terraces for any condition. This derivation is given under the heading "Diagram of Elements of a Terrace" in Fig. 2. Thus the vertical interval for terrace spacing which will give a minimum average soil loss from the interter-

raced area to the terrace channel is

$$\text{V.I.} = \left(\frac{m}{n-1} - 1\right)\left[b + S\left(b + t + \frac{b}{s}\right)\right] + S\left(b + t + \frac{b}{s}\right)$$

For illustrative purposes a specific group of values $m = 1.4$, $n = 1.6$, $b = 3$ ft, $t = 2$ ft, and $s = 0.20$ ft per ft are substituted in the theoretical equation for vertical terrace interval (V.I.), which will then reduce to

$$\text{V.I.} = 1\tfrac{1}{3}\,b + 11\tfrac{2}{3}\,(bS + S)$$

In the diagram at the top of Fig. 3 this equation is plotted for 1, 1½, and 2-ft height terraces. If the theory presented is correct, the size of a terrace is a factor to be considered from a soil loss viewpoint in terrace spacing recommendations. Plotted on the same diagram are the average terrace spacing recommendations given in a bulletin[1] for the southern and northern states. It is a point of interest that the spacing shown for the 1.5-ft height terrace follows the average of present recommendations very closely.

The sketch on the lower portion of Fig. 3 is used to show the increase or decrease in vertical interval necessary to produce an increase of 2 per cent in the minimum average soil loss per unit area from the interterraced area to the terrace channel. The height of the terrace used in the illustration is 1.5 ft and other dimensions are identical with those defined in the preceding paragraph. It is apparent that a considerable latitude of spacing will make only a slight difference in the average soil loss per unit area. This conclusion is supported by field data. Terraces located on the Bethany experiment station with vertical spacings of 5, 7, and 9 ft on a 13 per cent slope have had an average soil loss of 1.28, 1.31, and 1.28 tons per acre per year for a 7-yr period. Similar terraces with vertical spacings of 3, 5, and 7 ft on a 7 per cent slope have an average soil loss of 0.54, 0.88, and 1.29 tons per acre per year. Inasmuch as the error in measurement is approximately 8 per cent and soil variables exist within the experiments, it is possible that these factors are of greater consequence than the various spacings being studied.

TERRACE EFFECTIVENESS

Difficulty has been encountered in properly evaluating the effectiveness of terracing from a soil loss viewpoint on field experiments set up to study the problem. Soil loss as ordinarily measured from a terraced field is the amount carried from the field in runoff. Deposition in the terrace channel is not taken into account excepting as measured by profile readings taken along soil movement lines in the direction of land slope.

By use of the equation for total soil loss a speculative comparison of soil loss on a given slope will be made for a terraced and unterraced condition. Soil loss from the terraced slope will be considered the total amount moved to the terrace channel by runoff. Soil loss from the unterraced slope will be considered the total amount moved to the bottom of the slope length being compared.

Total soil loss to the terrace channel X_o from a unit width strip above the first terrace placed on a slope and the front slope of the terrace ridge may be determined from the expression

$$X_o = C\left[\left(\frac{SL_1 + \frac{Y}{2}}{L_1}\right)^m L_1^n + s^m\left(\frac{b}{s}\right)^n\right]$$

This assumes that the spacing of the first terrace will be identical with the remaining terraces on the slope.

[1]Hamilton, C. L. Terracing for soil and water conservation. U. S. Dept. Agr. Far. Bul. 1789, 1938.

Total soil loss to the terrace channel X_1 from a unit width strip from the interterraced area and the front slope of the terrace ridge may be determined by the expression

$$X_t = C\left[S_1^m L_1^n + s^m\left(\frac{b}{s}\right)^n\right]$$

Total soil loss X from a unit width strip on the unterraced slope may be determined by use of the equation

$$X = CS^m L^n$$

Ratios of total soil loss per unit width strip (unterraced slope to terraced slope) may be determined for the horizontal distances at which terraces are placed.

$$\text{Ratio} = \frac{X}{X_o + (\text{number of terraces} - 1)\,(X_t)}$$

Illustrative values of the various factors for determining this ratio are chosen as follows: m, the exponent of degree of slope = 1.4; n, the exponent of horizontal length of slope = 1.6; h the height of the terrace = 1.5 ft; S, the original slope of the land = 0.07 ft per ft; b, width of bottom of terrace channel = 3 ft; t, width of terrace ridge top = 2 ft, and s, slope of the terrace front-slope = 0.2 ft per ft. The horizontal spacing for this terrace L_2 for minimum average soil loss per unit area to the terrace channel according to the derived equation is 57.6 ft. The horizontal length of the terrace front-slope h/s is 7.5 ft. The vertical distance Y added to the original slope is 2.375. The horizontal length L_1 of the interterraced spacing producing a minimum average soil loss per unit area to the channel is 45.1 ft and the slope of the interterraced area S_1 is 0.123 ft per ft.

Table 1 gives the value of the ratios obtained for the assigned values of the factors involved. A brief inspection of the table shows that an increased soil loss has been produced by placing the first terrace on the slope. Soil is conserved on the remainder of the slope.

TABLE 1.

Horizontal distance, ft	Terraces from top of slope, number	Ratio $\frac{X}{X_o + (\text{number of terraces} - 1)X_t}$
57.6	1	0.81
115.2	2	1.15
172.8	3	1.43
230.4	4	1.68
288.0	5	1.91

SUMMARY

A rational equation for soil loss as affected by degree and length of slope is applied to the problem of terrace spacing and terrace effectiveness.

A theory of terrace spacing is evolved as follows: *When terraces of a given dimension are placed on a given slope, there is a length of interterraced spacing which will produce a minimum average soil loss per unit area from the interterraced area to the terrace channel.*

A theoretical equation for terrace spacing, based on the theory presented, is given and compared with present recommendations for a specific group of values of the factors involved.

It is believed that a considerable latitude of terrace spacing may be used and produce only a small variation in the average soil loss per unit area between terraces.

The dimensions of a terrace are a factor to be considered from a soil loss viewpoint in terrace spacing recommendations.

A theoretical equation is given for determining terrace effectiveness. This is illustrated with specific values assigned to the factors involved.

Instruments for Hydrologic Research

By W. H. Pomerene
ASSOCIATE A.S.A.E.

AT THE fall meeting of the American Society of Agricultural Engineers in 1938 it was suggested that an index of instruments commercially available for use in the study of hydrology and meteorology be prepared. The author has since prepared such an index, and in doing so an effort has been made to obtain information from all American instrument manufacturers and also from foreign manufacturers having representatives in this country.

These instruments are classified for purposes of listing in functional groups. The index lists over 200 different instruments made by some 60 different manufacturers. It is believed members of this Society are familiar with many of the standard hydrologic instruments and discussion will be limited to brief remarks of a few of the newer, or less widely known, instruments and attachments which it is thought warrant more description than is given in the index. These include the following:

Tachometer. This is used in velocity measurements with current meters. The instrument operates electrically, current being supplied by two small batteries in the instrument case. Reading is in revolutions per second with ranges of 0-5 and 0-10 revolutions per second available on the same instrument. Reading is not affected by resistance of circuit to meter, and an adjustment is provided for battery strength. This tachometer weighs about 10 lb and can be used with most of the standard types of current meters now in use, but requires a special contactor giving four contacts per revolution of the meter. If used with a multiple cable, two or three current meters can be operated with one tachometer, each meter being switched in in turn for reading, which requires only about five seconds. This makes the instrument particularly applicable for use on small streams where rapid changes of stage make time an important factor in gaging.

Current Velocity Indicator. This is used in conjunction with a standard Price current meter and automatically integrates impulses for periods of 15-60 sec. Readings are directly in feet per second. Ranges are provided from 0.15 to 10.0 ft per sec. It must be calibrated to the particular current meter with which it is to be used. Total weight of instrument and batteries is 10 lb. The instrument eliminates the human element in making these observations and gives the operator time to record other data.

Azimuth Meter. This consists of two units, one enclosed in a 60-lb weight which takes the place of the counterweight used with the current meter. This is electrically connected by a special cable to a surface unit which gives the direction of the current with reference to the magnetic meridian. Electricity for operation is supplied by a three-cell motorcycle battery. If used with a standard current meter, it will enable an observer to determine direction and velocity of subsurface currents, and it is claimed that if carefully used it is accurate to 3 deg.

Telemetering. The flood control programs being started in various parts of the country make it necessary for engineers in charge of flood gates and other control structures to know stream levels at many points during storm periods. There is now considerable demand for instruments to give this information. One of the most interesting of these which has developed may be connected to a public telephone line, and when called from any telephone the instrument will by means of a code signal of dots and dashes give the gage height at that point.

Instruments are also available for transmitting and indicating or recording at long distances readings of gage heights, pressure, temperature, etc. Several methods of transmitting this information are available as follows:

1 Pneumatic and hydraulic methods are available and are applicable for distances up to several hundred feet.

2 Transmission by means of position type motors is possible. This method uses a special type of synchronous motor at both transmitter and receiver, the fields of both motors being connected by three wires. Both motors must be supplied with alternating current from the same phase of the same system. The current used is normally 110-volt a.c., and as three or five wires are required between the two instruments, cost of line construction usually limits this method to relatively short distances.

3 Low-tension direct-current systems can be used. These systems use connecting lines of telephone type construction and can be used over distances of many miles. Several distinct methods of transmitting over these lines may be used.

(a) Systems are available which depend on strength of current received. With these systems the sending instrument may be either a rheostat transmitter or a special translator operated by 110-volt a.c. The receiving instrument is an indicating or recording milliammeter. One or two line wires are ordinarily used, but if greater accuracy is required, a three-wire bridge circuit may be used to eliminate variations in line resistances.

(b) A second type of low-tension system is that in which one impulse is sent for each change in gage height of a definite amount. This system requires direct current at the sending end and direct or alternating current at the receiving end. One, two, or three connecting wires may be used.

(c) A third type of low-tension system is that in which the action is dependent on the length of impulse transmitted. With this method impulses are sent out by the transmitter at short intervals, the length of each impulse varying with the gage height. The receiving instrument corrects itself as each impulse is received. Alternating current is required at both sending and receiving stations. Two wires are used for transmission.

Rainfall records may be transmitted long distances by use of tipping bucket rain gages with electrical contacting and receiving attachments. There is also available a rain gage using a float recorder with a reservoir holding 10 mm of rainfall which empties when full by syphonic action. Each filling of this reservoir may be recorded at long distance by use of an electrical contactor and recorder.

Presented before the Soil and Water Conservation Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 7, 1939. The author is assistant agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture.

EDITOR'S NOTE: The list of instruments referred to in this paper is available in mimeographed form. One copy will be sent to any A.S.A.E. member on request and without charge. Additional copies to members and copies to non-members of the Society may be obtained at a price of 20 cents per copy. Address Secretary A.S.A.E., St. Joseph, Michigan.

The Farm House and the Architect

By Fred M. Overby

AT NO time have houses been subjected to as thorough and careful analysis as they have received during the past few years. The current problems are of great interest and importance to everyone concerned, and are getting the attention and constructive criticism of some of the best engineering minds in the country.

In order to raise farm living to a higher plane, in so far as modernity is concerned, new farm homes of the future should be patterned as far as practicable after the city or urban house which, in addition to its many modern improvements and conveniences, generally has nearly all of the practical requirements of the farm house.

As is the case with the average city home, especially those of low cost, the great majority of farm houses do not have the benefit of architectural services. This is particularly true in the low-cost farm house, for which there is by far the greatest need. It is a known fact that as the cost of the new house decreases, so does the chance that the owner can afford an architect's fee. In cities, this problem has been approached from many angles, but as yet no satisfactory solution has been found. This applies in a greater degree to farm houses, because the architectural profession has not been interested in or given very much attention to the farm house. In addition, the farmer, like many a city dweller, does not employ an architect because very often he lacks the appreciation of the importance of proper design and competent supervision, and he cannot understand why he should pay a professional fee for these services. As a result, farm house design has received little attention from architects, or even from the farm people themselves. The family is not usually qualified to study housing problems, and in building a home, they are inclined to be satisfied with one "like their neighbor's new house", or with anything that is an improvement, however slight, over the old one. Habit and custom often dominate comfort and convenience.

ARCHITECTURAL CONSIDERATIONS OF STOCK PLANS

Assuming that an architect is not employed, and stock plans are the solution, individual requirements must be averaged as a basis for any plan for general distribution so that, even though a number of identical houses were to be built in the same locality from stock plans, the farmer would still have a distinctive home. Because of the distances between farmsteads, the natural variation in building sites, and through the use of different materials, painting, landscaping, etc., this result should be easily achieved. Then, too, it is logical that in most all cases, the farmer will not build from a stock set of plans "as is" but will want some revisions, additions, or omissions. If the thinking on the part of those who make up the stock plans is in terms of average requirements for the locality, the plan will be the right basis for the farmer's thinking, and the final results will be much better than without the use of a well-thought-out plan. The danger of standardization to any great degree is remote.

The farm home of tomorrow can be made more convenient and practical, more comfortable, more pleasing in appearance, and lower in cost than present-day farm houses by following unit construction methods, and by the use of ready-cut bulk lumber and other fabricated bulk materials. New uses for materials now available are being introduced, and new materials are being developed. The effect of mass production in lowering prices of standard plumbing, heating, and electrical equipment, standard kitchen equipment, and a host of other products is most pronounced.

Rapid progress is being made toward the improvement of present construction methods. Each year sees the introduction and use of new refinements tending to reduce erection time, waste, and labor costs on the job. Increasing numbers of specific-use parts are being adapted to the job. Building a house is becoming more and more an assembly job. Just as the stud framing system gradually grew from the heavier post and girt system, so are changes taking place in our present methods. We are thoroughly familiar, of course, with the need for further improvement to reduce costs. However, the progress made to date is sound, and readily understood by the contractor, carpenter, and retail dealers. The foregoing statements, of course, do not refer to prefabricated construction.

ONE-STORY FARM HOUSES

Because the greatest demand is for low-cost farm houses, the smaller farm homes are becoming more popular. This applies particularly to one-story homes. The one-story home can often be planned to include all of the conveniences and space for farm activities, since modern equipment makes possible a more compact plan. The farm home without a dining room is no longer uncommon.

More and more the farmstead is beginning to have the modern farmhouse as its main building. Until the last few years, the barn dominated the farmstead, particularly in the north central states, due to its comparative bulk and the many uses to which it has been put. However, the new farm home is rapidly becoming the center of the farmstead because within its walls the administration of the farm takes place, as well as many of the duties which were once performed elsewhere. It is a recognized fact that until recently more research has been undertaken on farm buildings other than the house. For instance, more thought and painstaking efforts have probably been expended in the placement of hog and poultry house windows than farmhouse windows.

The use of new lumber products and new methods can be of great assistance in reducing construction costs. Instead of planning room sizes to even feet, as is so often done, the layout can be arranged to permit the use of exact-length joists without cutting or fitting. Waste is eliminated, and no unnecessary overlapping of the joists is allowed. Ceiling heights can be dimensioned so as to provide for the universal use of an 8-ft exact-length stud with accurately squared ends. As with the joists, each stud may be used just as it comes from the dealer. With the ever-increasing popularity of interior wall finishes other than plaster, this factor is important, because such finishes as plywood, Nu-Wood, Celotex, and other boards come in 8-ft lengths, and the 8-ft stud facilitates their use. There are about 250 studs in the average house. If each stud were to

---

An abridgment of a paper presented before the Farm Structures Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, December 5, 1939. The author is an architect for the Weyerhaeuser Company.

be measured, squared, and cut at both ends, it is evident that preparing the studs would take more time than placing and nailing them.

Much work can be eliminated in the framing for window and door openings by the use of precut headers, sills, jambs, and cripples, which arrive at the job in correct lengths for inserting between regularly spaced studding. Obviously, when numerous window and door openings of the same size have to be framed, it is necessary to perform a number of identical operations—fitting, measuring, squaring, and cutting—in order to obtain the necessary number of pieces. To overcome this difficulty, save on building time, and leave the carpenter with time for other more important duties, ready-cut units are available for door and window openings, which arrive on the job in bundles, with stenciled identification and instructions. Their use eliminates waste on the job, and the mills are also able to reduce their waste factor through the use of short pieces, with resultant saving in cost.

Full bearing of all framing lumber is fundamental in good house construction. In addition to the lower costs which result from the use of the joists, studs, and other items just mentioned, better construction also results because square ends and even surfaces come together to give full bearing of all framing members, making for stronger and tighter structures.

TIME-SAVING LUMBER

The average one-story house has over 2,000 items in the rough framing alone. Imagine the work of cutting every single piece by hand. That was done not so long ago, but true and square ends did not always result.

Another important item in simplifying and speeding up construction with less waste and less labor time has been the development of end-matched or "endless" lumber, which may be used for subfloors, wall sheathing, and roof sheathing. Each piece is tongued and grooved on the ends as well as the edges. When applied, it meshes together to form strong, tight walls. The only cutting necessary is at the openings and corners, and there the piece that is cut off may be used to start the next run. Because the ends of the boards interlock in a firm tongue-and-grooved joint, pieces do not have to be joined over framing members, as is required when plain square-end lumber is used. The result is that this sheathing goes on faster, and is easier to apply, requiring no special skill on the part of the user; and there is practically no waste. Nailing time is also substantially reduced because fewer nails are used. Drop siding, finish flooring, and finish ceiling are also available with the same features.

Joists, studding, and sheathing are the three most important framing items and make up the greatest number of board feet on the job. The use of these items as just described is an important factor in keeping down the cost of the house. Accurate checking during the construction of a house which was planned to gain the greatest use out of exact-length joists and studs and end-matched sheathing has shown that as much as 67½ per cent of the board feet used was in pieces untouched by a saw on the job.

Among many of the other improved lumber items could be mentioned packaged bevel siding and exterior finish, packaged mouldings, interior board wall finishes, plywood, wood gutters, stepping, and shingles. Then, too, you are all more or less acquainted with the new complete units ready for installation, such as weatherstripped windows and frames, sectional kitchen cabinets, china cabinets, fireplace mantels, and stair rails. When products such as these are specified in a farm house, the reduction in building costs due to labor time saved and waste eliminated is obvious.

The farmer also needs assistance in the selection of the correct lumber species for building, which is of basic importance in good house construction. The job of matching the correct lumber to the specific building need has been done by building engineers and experienced construction men.

Exterior appearance of a home is probably just as important as the plan itself. One's home should be a constant source of pride, and to make it so, good design is necessary. Good architectural design which aims at honesty of expression and simple, pleasing lines need not add to the cost. Landscaping, too, has its place in farmhouse design.

FACTORS DELAYING FARM HOME IMPROVEMENT

Just what are some of the reasons for the pressing need for new farm homes today? In a good many cases, it is undoubtedly true that until recently new farm homes have not been built, or old ones modernized, simply because the farmers, being comparatively isolated from others, are more or less inclined to be satisfied with their environment because they have become so accustomed to it. However, in recent years the trend seems to be away from that attitude. In spite of the fact that much of rural housing in the past has been needlessly substandard, a gradual rise in the standards is evident. For instance, the 1930 census indicated that about 15 per cent of the farm houses tabulated had water piped into the house, while recent figures published by the U. S. Department of Labor indicate that this percentage has increased substantially.

Of course, there are many farm homes where modern comforts cannot possibly be made available, and there are many cases where the farmer is financially unable to have them.

There is possibly another reason for inactivity in farm building. Perhaps this backwardness can be traceable to the manufacturers of building commodities themselves, because until recently they have not been very aggressive in appealing to the farm trade. Through efficient advertising, the farmer has been reached by the manufacturer of automobiles, radios, improved household equipment, and others, while new house construction has suffered. To assist in overcoming this condition, the agricultural colleges, manufacturers, farm magazines, and the government should continue their efforts to furnish plans, specifications, material lists, and other information to the farmers, and in every way possible give them the full benefit of technical and professional experience without extra cost. Manufacturers, colleges, and industrialists, through scientific research and inventions, have done much and can do more to bring comfort to the modern farm home.

Building codes are lacking, for the farm, that might aid in regulating materials that go into the home. Requirements for health and sanitation are lacking. Casual evidence shows that owing to the local methods of building in rural sections, there is a great difference in fundamental building practices, with resulting waste in materials and inefficiency in construction. If minimum requirements could be grouped together for educational purposes, it would be a big step toward improvement in farmhouse construction. Lumber dealers, carpenters, contractors, and farmers would welcome such information.

It is reasonable to believe that an approach is being made to the well-planned, low-cost farm house, through such methods as those just discussed. The farmer can build a good, low-cost home without using radically new types of construction if the manufacturers, colleges, and government will assist him by furnishing the engineering and architectural advice so necessary in all good construction.

Single Versus Dual Pneumatic Tires

By E. C. Sauve
MEMBER A.S.A.E.

FEW would deny that, if a pneumatic tire of a certain size gives reasonable tractor traction, the addition of a second tire in dual combination would increase the traction. However, with increased traction came increased cost of the wheel equipment, which mitigated against wide acceptance by tractor owners.

Manufacturers of pneumatic tires soon began to design and build tractor tires with smaller cross sections than were formerly available, with the thought in mind that perhaps two tires of small cross section could be manufactured as cheaply as one large tire. Once a comparable cost was determined, it was in order to test their relative merits, based solely on their ability to produce traction.

At this point the stage was set for the participation of Michigan State College, in cooperation with the Goodyear Tire and Rubber Company, in an attempt to answer this debatable question of tractor traction. Livingston Farm located in Clinton County, was selected as the place of conducting the tests because of the many variations of soil types and soil conditions.

A new two-row cultivating type tractor was obtained for the tests. Suitable rims and tires, as well as a traction dynamometer, were supplied by the Goodyear Company. The tire equipment for the traction members consisted of two 9.00-36 tires and four 5.00-44 tires, the latter arranged in dual combination. The dynamometer consisted of truck elaborately designed to accommodate various recording devices. These devices are all placed in the cab of the truck, readily accessible to the observer. Specifically, they include five electric counters, a stop watch, a load indicating dial, a truck engine throttle control, and suitable switches and valves. Three of the five counters were used in the determination of tractor slippage. One of these counters was connected electrically to a bicycle ground wheel, while the other two were connected to small wheels which were driven by the side walls of the tires under test. Contact breakers were supplied in the wheels to make possible counter recordings. These counter readings were used in establishing ratios from which traction wheel slippage could be calculated in per cent.

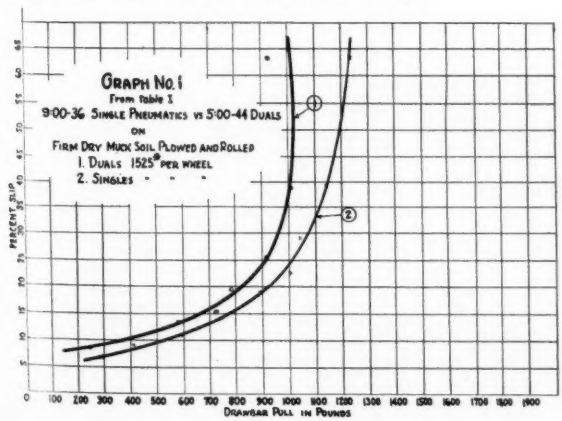
The two remaining counters were connected to a load integrator. This integrator also had electrical contacts. A ratio of these counter-readings with the aid of a calibration curve made possible fairly rapid recordings of drawbar pull. The pull of the tractor was transmitted through an oil dynamometer of the diaphragm type, the pressure of the oil acting on a Bourdon tube. As the load varied, the disk attached to the Bourdon tube also varied positions in relation to its driving disk. Thus different ratios were established proportionate to the load change. A second but smaller dynamometer was employed for the push tests. A two-way valve connected one or the other of the dynamometers as required.

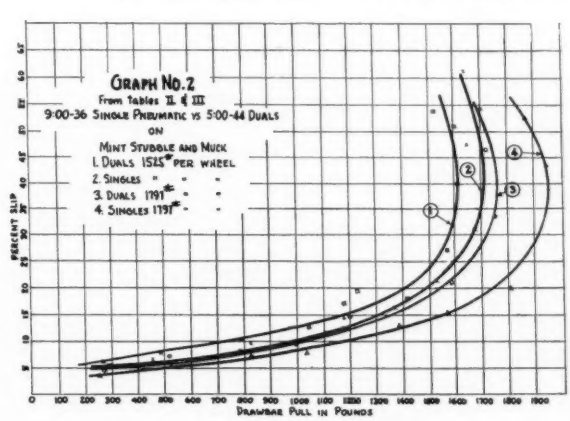
During the test the manual operation of a push button electrically set all five dials and stop watch in motion at the same time, and at the conclusion of the test the same push button stopped all dials simultaneously. The load on the tractor drawbar was regulated by a thumb screw adjustment which was connected to the throttle of the truck engine. To apply an increase in load, the truck engine was slowed down by means of this throttle adjustment. To decrease the load the truck engine was speeded up, thus releasing the load. Very fine loading increments were possible with this throttle control.

TABLE 1. TRACTOR PERFORMANCE IN MUCK SOIL, WITH SINGLE AND DUAL TIRES, 1525 LB ON EACH WHEEL

	9.00-36 Singles—1525 lb				5.00-44 Duals—1525 lb			
	Drawbar pull, lb	Slip, per cent	Speed, mph	Drawbar hp	Drawbar pull, lb	Slip, per cent	Speed, mph	Drawbar hp
Push	555	0	1.9	2.80	645	0	1.85	3.18
"	560	0	1.83	2.70	672	0	1.85	3.36
"	650	0	1.66	1.66	735	0	1.80	3.53
Pull	290	6.8	2.38	1.84	250	8.6	2.36	1.57
"	410	9.0	2.31	2.50	400	10.2	2.32	2.48
"	590	11.1	2.26	3.56	580	13.4	2.25	3.48
"	740	14.0	2.18	4.30	720	15.4	2.18	4.18
"	890	18.8	2.04	4.84	780	19.7	2.06	4.28
"	1000	22.6	1.94	5.17	910	25.5	1.92	4.66
"	1040	29.2	1.77	4.9	920	63.8	0.91	2.23
"	1140	39.5	1.50	4.56	1000	39.1	1.55	4.14
"	1230	63.7	0.90	2.95	1000	65.5	0.83	2.22

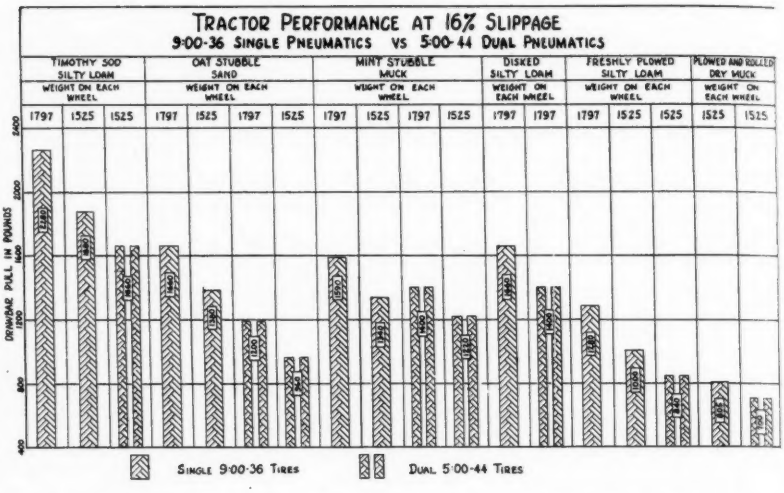
Presented before the Power and Machinery Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 5, 1939. The author is assistant professor of agricultural engineering, Michigan State College.


GRAPH NO. 1
From Table I
9:00-36 SINGLE PNEUMATICS VS 5:00-44 DUALS
ON
FIRM DRY MUCK SOIL PLOWED AND ROLLED
1. DUALS 1525# PER WHEEL
2. SINGLES " " "
PERCENT SLIP
DRAWBAR PULL IN POUNDS


GRAPH NO. 2
From Tables II & III
9:00-36 SINGLE PNEUMATIC VS 5:00-44 DUALS
ON
MINT STUBBLE AND MUCK
1. DUALS 1525# PER WHEEL
2. SINGLES " " "
3. DUALS 1791# " "
4. SINGLES 1791# " "
PERCENT SLIP
DRAWBAR PULL IN POUNDS

Tests were conducted on three soil types, namely, silty loam, sand, and muck. The condition of the soils was highly favorable to good traction and low slippage because the soil was dry. There was but one light rain which fell during the 10-day test period. The results and conclusions of this report, therefore, do not necessarily apply to soils with high moisture content.

The plan in mind for conducting these tests was to eliminate all variables except tire traction on soil. For example, the tractor was carefully weighed with operator. The different wheel assemblies and wheel weights also were carefully weighed. Thus, for each comparative test the weight on the traction members of the tractor was the same for the single-pneumatic-tired tractor as for the dual-pneumatic-tired tractor.


TRACTOR PERFORMANCE AT 16% SLIPPAGE
9.00-36 SINGLE PNEUMATICS VS 5.00-44 DUAL PNEUMATICS
TIMOTHY SOD SILTY LOAM
OAT STUBBLE SAND
MINT STUBBLE MUCK
DISKED SILTY LOAM
FRESHLY PLOWED SILTY LOAM
PLOWED AND ROLLED DRY MUCK
WEIGHT ON EACH WHEEL
DRAWBAR PULL IN POUNDS
SINGLE 9.00-36 TIRES
DUAL 5.00-44 TIRES

The tires were inflated with air as recommended, that is, 12 lb air pressure for the singles and 20 lb for the duals.

Tests were made comparing single and dual pneumatics for the following six conditions: (1) Timothy sod, (2) sand (oat stubble), (3) muck (mint stubble), (4) muck (plowed and rolled), (5) freshly plowed and disked ground (silty loam), and (6) freshly plowed ground (silty loam).

Space does not permit recording all tests in table form. However, Tables 1, 2, and 3 and Graphs 1 and 2 show typical performances of these tires under test.

A tractor performance chart, covering all tests, is also shown. The complete report of tests will be found in the Michigan Agricultural Experiment Station Quarterly Bulletin, Vol. 22, No. 2, November 1939.

An analysis of the tables and charts indicates quite definitely that the single pneumatics show a traction advantage over the dual pneumatics for the same percentage of slip.

Referring to Graph No. 2, it will be seen that the addition of weights to the traction members also increases the traction of both sets of wheel equipment for the same per cent of slip.

It must be clearly understood that this report deals only with a comparison of 9.00-36 single pneumatics with 5.00-44 dual pneumatics. The tests were conducted on soils in a fairly dry state, which contributed to favorable traction of the tire equipment. *(Continued on page 109)*

TABLE 2. TRACTOR PERFORMANCE IN DRY MUCK (MINT STUBBLE) WITH DUAL AND SINGLES TIRES, 1525 LB ON EACH WHEEL

	5.00-44 Duals—1525 lb				9.00-36 Singles—1525 lb			
	Draw-bar pull, lb	Slip, per cent	Speed, mph	Draw-bar hp	Draw-bar pull, lb	Slip, per cent	Speed, mph	Draw-bar hp
Push	408	0	2.58	2.81	420	0	2.81	3.15
"	450	0	2.50	3.00	438	0	2.20	2.57
"	388	0	2.73	2.83	385	0	2.36	2.32
Pull	270	5.13	3.28	2.36	290	5.7	3.21	2.48
"	490	8.10	3.19	4.17	460	6.87	3.16	3.88
"	800	10.70	3.04	6.49	830	9.76	3.03	6.70
"	1050	13.00	2.97	8.32	1040	10.5	3.02	8.38
"	1180	17.50	2.81	8.84	1180	14.9	2.85	8.98
"	1230	19.80	2.71	8.90	1370	16.65	2.76	10.08
"	1420	18.50	2.75	10.42	1530	21.7	2.59	10.55
"	1530	54.4	1.46	5.97	1640	61.2	1.24	5.43
"	1570	27.4	2.45	10.25	1650	47.6	1.71	7.52
"	1600	51.3	1.58	6.74	1680	38.4	2.03	9.10

TABLE 3. TRACTOR PERFORMANCE IN DRY MUCK (MINT STUBBLE) WITH SINGLE AND DUAL TIRES, 1797 LB ON EACH WHEEL

	9.00-36 Singles—1797 lb				5.00-44 Duals—1797 lb			
	Draw-bar pull, lb	Slip, per cent	Speed, mph	Draw-bar hp	Draw-bar pull, lb	Slip, per cent	Speed, mph	Draw-bar hp
Push	453	0	2.59	3.13	485	0	2.52	3.26
"	488	0	2.52	3.28	517	0	2.63	3.62
"	420	0	2.64	2.96	455	0	2.67	3.24
Pull	260	3.89	3.19	2.22	280	4.63	3.28	2.45
"	530	5.47	3.14	4.44	520	7.28	3.18	4.41
"	830	8.00	3.06	6.77	790	8.38	3.14	6.61
"	1040	8.83	3.02	8.38	1000	9.8	3.05	8.13
"	1110	11.83	3.01	8.92	1200	15.0	2.86	9.17
"	1390	13.4	2.90	10.75	1590	21.4	2.63	11.15
"	1570	15.9	2.77	11.6	1750	33.9	2.08	9.71
"	1810	20.5	2.57	12.5	1720	46.7	1.49	6.84
"	1950	43.8	1.61	8.38	1700	54.4	1.20	5.44

DYNAMOMETER TRUCK AND TRACTOR (LEFT) TESTING SINGLE TIRES AND (RIGHT) DUAL TIRES

Drainage Investigations of the Farm Credit Administration

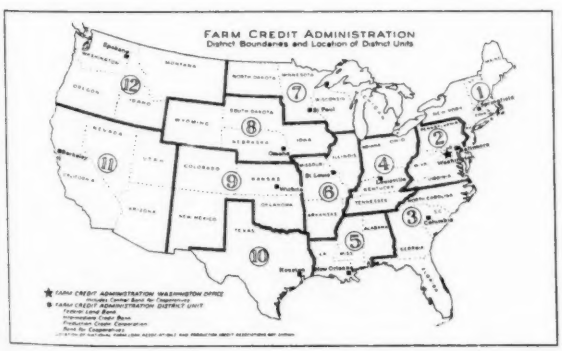
By Don H. Bushnell

THE federal land banks, for which the drainage investigations discussed in this paper are conducted, were organized under authority of the Federal Farm Loan Act of 1916 to make long-term farm mortgage loans throughout the country. There are twelve of these banks, each of which serves a certain group of states, as shown on the accompanying map. They are cooperative institutions, semiprivate in character, which have been assisted in their organization and operation by loans from the federal treasury. In general, they operate as separate units under the supervision of the Farm Credit Administration, an agency of the federal government.

Sometime after their organization, those banks loaning on farms affected by drainage, irrigation, and flood control projects realized that they would require technical advice on the economic factors common to such projects in order to make sound loans which they could expect to be retired over a long term of years under changing project conditions. In line with this reasoning, engineering departments were established in all of the banks, except those at Springfield, Mass., and Baltimore, Md. The Appraisal Engineering Section of the Farm Credit Administration in Washington supervises the work of these departments and also handles the few engineering problems that arise in connection with the operations of the two banks that have no engineering departments.

The men who carry on what is termed engineer-appraisal work, have a thorough practical knowledge of the problems involved in the organizing, financing, construction, and maintenance of reclamation projects, as well as an understanding of sound appraisal and lending procedure. Since this type of work has not been undertaken to any material extent by lending agencies other than the land bank system, it has been necessary in obtaining new men to select engineers qualified by education and practical experience in drainage or irrigation work, then train them in matters of appraisals and extension of credit. Such men are obtained from civil service registers.

Presented before the Soil and Water Conservation Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 7, 1939. The author is assistant chief, Appraisal Engineering Section, Farm Credit Administration, U. S. Department of Agriculture.



These engineer appraisers investigate and report on matters of drainage, irrigation, flooding, and a variety of other special problems of an engineering nature. With the exception of a relatively few drainage enterprises in the western states and of the drainage districts formed in irrigation areas, most of the drainage projects reported upon are situated in the humid sections in the South and Middle West, as can be seen on the accompanying map prepared by the Bureau of the Census. It is intended to confine this discussion to the activities relating to the investigation of drainage projects in the humid region.

The type of information and advice developed concerning these districts is designed to assist land bank appraisers in making appraisals for new loans on farms therein and to guide the banks in servicing loans previously made. In the case of a farm not situated in an organized district that provides artificial drainage, an appraiser can easily observe the natural drainage afforded and value the property accordingly. In the case of a farm in a drainage district, however, often the property is affected by a district debt for which it is partially liable. It also is dependent to a large extent on the attitude of the majority of the district landowners for maintenance of a satisfactory outlet for its drainage. It is evident, therefore, that in the latter case an appraiser must have some supplemental information on the district as a whole before he can place sound values on a particular farm in the area.

The chief factors concerning a drainage district, upon which advice ordinarily is needed in making loans are:

1 The amount of the district debt that will have to be retired by each farm, taking into account any lands which are incapable of bearing their share of the debt if individual liability is not limited by statute.

2 The annual charges that will have to be levied against district lands to retire the debt.

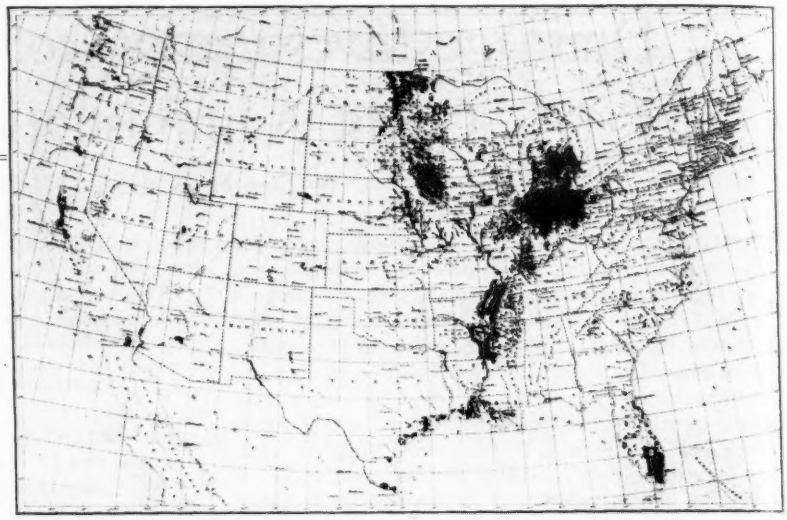
3 The probability of the district incurring an additional debt to complete, improve, or extend its drainage system.

4 The adequacy of the drainage afforded by the system in its present condition.

5 The probable future adequacy in the light of past history of the district's maintenance policy.

6 The annual charges which will have to be levied against district lands to maintain the drainage system.

In the preparation of a report on a drainage district, an engineer-appraiser gathers and studies data from public records concerning the financial condition of the district, its future maturing obligations, and past history of operations as a guide to what may be expected to occur during the term of any loans that may be made in the area. He does not make a detailed field survey of the physical works of the project, but studies, when available, the plans under which the drainage system was constructed. He inspects the district lands and improvements, observing and discuss-



DRAINAGE DISTRICTS IN THE UNITED STATES. DISTRICTS ARE INDICATED BY BLACK AREAS

ing with the local people the efficiency with which farms in the district are served. From these studies he is able to form conclusions regarding the desirability of the area as a loan field, any hazards to loans that should be pointed out to appraisers and to the bank, and the steps necessary for the district to take to remedy any unsatisfactory conditions. The data assembled are made a part of the report on the district, which also contains conclusions and a definite recommendation of a loan policy to be followed in the area. Such reports are brought up to date every few years by preparing supplements based on current information.

In general, engineer-appraisal reports have been prepared for practically all drainage districts, except for those in certain portions of Iowa, Illinois, Indiana, Ohio, and Michigan, where drainage is a relatively simple matter, project conditions have become stabilized through long existence, district costs are small in relation to farm values, and usually the drainage systems are fairly well maintained. The data thus compiled over a period of years probably constitute the most comprehensive record on drainage districts of the country in existence today for, as far as we know, no other agency has attempted similar investigations over such a wide area.

While the engineer-appraisers who prepare these reports are appointed by the Farm Credit Administration, most of their salaries and other expenses of the engineering departments in the banks are borne by the banks. For this reason, the reports prepared by engineer-appraisers in most respects are considered to be the property of the individual banks. They are confidential in nature and, except under special circumstances, are not made available to individuals and agencies outside the land bank system. All the banks, however, have shown a desire to cooperate with any agency attempting to improve conditions in the areas reported upon. They realize that any constructive results obtained by such an agency will react to the benefit of the banks' borrowers, as well as to other landowners who may wish loans in the future.

In this connection, the factual information contained in the reports has been made available to a number of federal agencies by allowing the complete reports to be studied either in the banks or in the Washington office of the Farm Credit Administration, with the understanding that matters pertaining to loan policies are to be held in confidence. In some instances the factual data have been abstracted for the use of outside agencies upon payment of the expense of such work or in exchange for assistance furnished by those agencies. Any agency desiring to consult these reports should contact the Farm Credit Administration in Washington or the engineer-appraisers in charge of the work in the various land banks.

The federal land banks do no drainage construction work, except on private drainage systems on properties they have acquired. Neither do they make a practice of attempting to influence the landowners' methods of operating their drainage projects. For the most part, they accept district conditions as they are and extend such loan service as they can under those conditions, although of course they realize that in many instances greater service could be rendered if the projects would do certain things to improve conditions. If, however, conditions are so hazardous that it is decided no loans can be made in a project, the landowners usually are informed of the reasons for that decision and in many instances have taken action to remedy the defects pointed out to them.

A great variety of defects has been found in the drainage districts investigated. I do not mean technical inefficiencies, to which we give little consideration, but practical deficiencies which often should be eliminated as they are costing the landowners money in reduced returns and constitute hazards to the making of farm mortgage loans. It is impossible to discuss very many of these in a paper of this nature, but possibly observations regarding a few which are most important will be of interest.

The retirement of the indebtedness incurred by drainage projects for construction of their systems is one of the most important problems in many areas. Often, either because the projects were too expensive in the first place, or the terms for repayment of the debt were unsatisfactory, the landowners have been unable to retire that debt in an orderly manner as scheduled. The Reconstruction Finance Corporation has assisted materially in readjusting the debts of many districts by refinancing them on a long-term, low-interest basis with a scaling down in the principal amount. There are, however, a great many projects which still have debts, the annual charges for which are more than the landowners can meet along with their private obligations and general taxes. Adoption of a businesslike policy of collecting assessment delinquencies and of straightforward negotiations with bondholders to readjust the term of years of repayment, the rate of interest, and possibly the total amount of the debt, should be undertaken in these cases. Aside from the obvious difficulties with which such defaulting districts are now confronted, those that do not make an honest attempt to solve their problems in an orderly manner undoubtedly will experience considerable difficulty in obtaining credit to provide for any necessary reconstruction in the future.

Another problem which is even more prevalent than that of defaults on district debts is the general lack of proper maintenance of project drainage systems. Of course, debt retirement difficulties have resulted in much neglect of maintenance, but they can be blamed in only part of the projects. It has been evident in our work that, as a whole, irrigation systems in the West are given better maintenance than are the drainage systems in the humid sections. One reason for this probably is that owners of irrigated lands can readily observe the effect of poor maintenance on their precious water supplies, but deterioration of a poorly maintained drain makes itself felt slowly. Often its full import is not realized by the majority of the landowners until a series of wet years causes them to suffer serious crop losses. Then the systems are repaired at a cost which, not counting the cost of the crop losses, usually exceeds that which would have been incurred had regular maintenance been practiced. The policy of "dig 'em and leave 'em" prevails too widely in most drainage projects, and is particularly prevalent in the South.

Our observations have led us to the belief that another very important reason for lack of proper maintenance of drainage systems is the form of management existing in the projects. In some cases, the affairs of districts are administered by boards composed of landowners who handle district problems only when they have the time to spare from their occupations. In others, the project affairs are handled by county boards of supervisors, many of whose members are not directly interested in the welfare of the districts. In a relatively few cases some individual is designated to look after the affairs of the projects, but in too many instances the maintenance of a project is everyone's business yet no one's direct responsibility.

Far too often the advice of a qualified drainage engineer is obtained only in the construction of a project, and thereafter he is not consulted about matters of maintenance. It seems probable that this is caused by the fact that many farmers feel it is a simple matter about which they are well informed. They refuse to believe, for instance, that brush and even trees growing in a ditch materially affect its efficiency. Engineers may be somewhat to blame for this situation in that they have not put across to the farmer, in language he understands, the idea that regular maintenance pays dividends and is not just an unnecessary technical nicety. As many of us have learned from experience, this thought is a hard one to get across to farmers.

The work carried on by the Civilian Conservation Corps drainage camps and by certain other agencies has been very productive in rehabilitating deteriorated drainage systems. It is to be hoped that the example of the benefits derived from this work will do much to educate those in charge of drainage projects in the soundness of properly maintaining their systems. In spite of the fine efforts of these organizations, however, their work has been limited in extent, and it is believed that their achievements must be supplemented by other endeavors if it is to be expected that proper maintenance ever will be practiced generally in drainage projects.

It seems that a study leading to revision of the drainage laws in some of the states might be the best approach to this problem. At present the laws of many of the states either require a large portion of the landowners to support instigation of maintenance work, or simply "permit" the project management to do certain work on the drains. They usually do not place definite responsibility upon anyone to see that the adequacy of the drainage service rendered to each and every landowner is maintained as intended. As a result, a few farms often are damaged by lack of maintenance of a part of a drainage system due to the fact that most of the lands in the project are unaffected. If the hodgepodge of state statutes could be revised to place the responsibility for project maintenance on certain qualified persons, preferably drainage engineers, whose actions would not be influenced by politics and whose interests would not be elsewhere, some definite results could be obtained which would react to the benefit of landowners in those drainage projects where maintenance now is neglected.

The efforts of drainage engineers in the past have been directed chiefly to the reclamation of unproductive lands by the construction of drainage systems. In this undertaking they have made a worth-while contribution to the development of the nation's resources. The field for further work of this nature now has become rather limited. Drainage engineers can make further contributions in the future, however, by endeavoring to devise means of placing the operation of existing projects on a sound business basis so landowners therein will receive the maximum benefits from their investments in the drainage systems.

Single Versus Dual Pneumatic Tires

(Continued from page 106)

SUMMARY

A summary of all tests comparing 9.00-36 single pneumatics with 5.00-44 dual pneumatics follows:

1 Traction, expressed in pounds pull on the tractor drawbar, was greater for the single than for the dual pneumatics for the same per cent slippage for all soils and conditions tested.

2 The advantage in traction gained by the single pneumatics over the dual pneumatics for a slippage of 16 per cent is as follows: Sand, 41.1 per cent; disked ground, 20.4 per cent; freshly plowed ground, 19 per cent; muck (plowed and rolled), 15 per cent; sod, 13.25 per cent; and muck (mint stubble), 11.7 per cent.

3 Increased weight on the driving wheels of the tractor increased the traction for the same percentage of slip.

4 At 16 per cent slip, the drawbar pull increase with the single pneumatics for 544 lb added to the traction members is as follows: Sod, 400 lb; sand (oat stubble), 280 lb; muck (mint stubble), 250 lb; and freshly plowed ground, 280 pounds.

5 At 16 per cent slip the drawbar pull increase, with the dual pneumatics for 544 lb added to the traction members, is as follows: Sand (oat stubble), 240 lb; muck (mint stubble), 180 lb.

6 Maximum drawbar pull was obtained with an average slippage of 45 per cent.

7 Maximum horsepower was obtained with an average slippage of 23 per cent.

8 The coefficient of traction, that is, the ratio of drawbar pull at 45 per cent slippage to the (zero load) weight on drive wheels, is as follows:

Muck (plowed and rolled) singles, 0.38; duals, 0.33
Muck (mint stubble) .....singles, 0.55; duals, 0.50
Silty loam (sod) .....singles, 0.90; duals, 0.82
Silty loam (freshly plowed) singles, 0.62; duals, 0.54
Sand (oat stubble) .....singles, 0.60; duals, 0.49
Silty loam (freshly plowed and disked) .....singles, 0.71; duals, 0.60

9 The effect of changing the spacing of the duals from the standard setting of 9 in center to center, to a 7-in spacing, did not appear to affect tractive ability, for the one comparison made.

Engineering Aspects of Handling Farm Chemurgic Crops

By H. E. Barnard

THE chemurgic program, now in its fifth year, is based on the belief that it is economically unsound for the farmer to stop working either his land or his labor. Rather it would find a new market for his crops—a market which will absorb the chemical raw materials he produces in the form of starch and sugar, protein and cellulose, at a price which will return him production costs and a reasonable return on his capital investment. Industrialists, now certain as never before that their success will be measured not so much by their ability to continue to produce old things as by the capacity of their research chemists, are making an amazing number of new things—new plastics, new sugars, new starches, new fabrics. These are the chemurgic developments which are already broadening the market for the farmers' crops and which have so aroused the public interest that today, as a part of the agricultural program, great industrial research laboratories are being built to discover additional values in farm crops and farm wastes.

LOWERING OF FARM COSTS IMPORTANT

The role of the agricultural engineers in this developing program is sharply defined. They must, by lowering production costs, help to supply the raw material needed in new industries at a price which will adequately compensate the farmer and at the same time successfully enter the competitive field.

How can production costs be lowered? There are many ways of doing this. The development of hybrid corn which increases the yield from ten to twenty per cent is a significant example of the ability of the plant breeder to lower the cost of corn at the farm. Improved methods of fertilization, of cultivating and handling the crop, farm practices which have been greatly improved by agricultural engineers, all contribute to the piling up of surpluses and all emphasize the need for the chemurgic program.

In the progress of our work we face the need for improvement in every division of the farmer's activities. We are just now learning the importance of mere traces of chemical elements in nourishing the growing crops. As we are learning a little about the importance of hormones in human well-being, we now realize that the plant hormones play a fundamentally important role. We are learning too how to secure maximum values from our food crops. If the protein content of wheat is too low for the making of desirable flour we know how to improve it. If meat is tough we know how to tenderize it. We have learned how to handle fruits in cold storage; quick freezing processes give us fresh fruits and vegetables throughout the year.

There are, however, a lot of things which we are not yet doing as easily and as economically as we should, and many crops which we can readily grow are now imported from lands where labor is cheap.

Sound sanitary practice replaced the early method of delivering milk by dipping raw and often unclean milk into containers at the kitchen door by introducing pasteurization and the use of sterilized glass bottles. Today a new package is coming into use, a chemurgic package made of paper which once used is discarded and which, by making milk sales at the grocery store as practical as the sale of eggs and bread, will markedly reduce delivery costs, stop bottle breakage, cut the weight of loaded milk trucks, and eliminate bottle returns. When paper packages are in general use the farmer who grows wood will have a market for many hundred thousand tons of pulpwood. And it may well be that some day his now wasted straw and cornstalks will not only feed his dairy herd but carry its milk to the family table. Certainly this development lies within the realm of the agricultural engineer.

We are much interested in the Italian product known as lanital. If Italian engineers and chemists can make a spinnable fiber from milk casein, it may be that we too can find some use for the billions of gallons of skim milk we now waste. We know that definite progress is being made in this direction and that milk casein paint is in profitable production. But there still remains to be developed some practical way of preparing casein at the small creamery so that it can be separated, dried, granulated, and packaged for shipment to larger plants where it can be converted to new uses. Such devices are being developed and some day the value of milk will no longer be measured by the value of its butterfat.

FARM OPERATIONS AND COSTS INFLUENCE PROCESSING PROBLEMS

In 1930 two million dollars were spent in building a modern plant for making paper from straw. The equipment was well designed and the processes worked satisfactorily, but four months after operations began they were stopped and the plant has been dismantled. If methods had been developed for gathering clean straw, compressing it into a solid bale of small bulk and delivering it to the paper plant at a cost comparable with the cost of wood pulp, straw would today have real value for pulping. Some day we shall cut down the labor costs of handling bulky materials which industry needs but must buy and use in competition with domestic and imported wood pulp and paper.

Down at Laurel, Mississippi, a factory is successfully making starch from sweet potatoes. The cost of that starch is largely determined by the cost of growing the potatoes. In the vicinity of the factory the average yield of sweet potatoes has been about 80 bu to the acre. I am told that this year a great many farmers are raising 300 bu of potatoes to the acre. This is a lot of potatoes to handle, and the farmer is still doing it in the same old way—with the mule, hoe, and basket. Of course, power is now available for handling the soil, but the farmer must find a way to cut out the hand labor required in setting the plants and in gathering the crop, and most of all, whether in the field or factory, some method must be devised for protecting the crop from spoilage before the starch content can be removed.

One of the most important problems now remaining to be solved has to do with removing the high water content

Presented before the Power and Machinery Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 6, 1939. The author is director of research, National Farm Chemurgic Council.

of grasses, fruits, and vegetables. Large farms with available capital are now dehydrating alfalfa and hay crops. Experimental or pilot plant operations are being developed for handling sweet potatoes. The old practices of drying fruit have progressed from the method our grandmothers employed when they strung sliced apple on frames and when burning sulphur stopped enzymic action. Drying methods have made marked progress in recent years, but it still costs too much to remove water in the curing of field crops and the dehydration of fruits and vegetables.

DOMESTIC PRODUCTION OF ORGANIC OILS AND FATS

Our farms produce adequate supplies of sugars and starches, and of proteins and cellulose, but we still go to the tropics for immense tonnages of fats and oils which should be grown here at home. Our most important fat crop is butterfat. We are steadily increasing its production and lowering its cost at the farm. Our next most important fat crop is cottonseed oil, and with the passing of the cotton crop to other countries where it can be grown far more cheaply than on the cotton lands which have supported the South for generations, we must find new sources for vegetable oils. It may be that peanuts, rich in oil, will meet the need, but we must develop methods for delivering the crop which will cheapen production costs. It may be, too, that the bald-headed cotton which has been developed at the Texas experiment station will make us less dependent on imported oils. This is a new crop, grown on the cotton plantation, but without linters or fiber. However, it cannot be profitably grown until certain qualities are developed in the plant which make for a large yield of oil-bearing seed which can be harvested just as the soybean crop is now harvested, without loss of seed by shattering. After the plant breeder has produced a cotton boll which does not open, it should not be difficult for agricultural engineers to adapt present harvesting machinery to this new use.

We import huge tonnages of nonfood oils—oils which find their important use in the paint and varnish industry. We go to South America for half our need for linseed oil. In normal times we have gone to China for tung oil. We import thousands of tons of castor beans which are rich in oil. All of these crops can readily be grown on our own lands.

The rapid expansion of flax acreage is a significant illustration. Within the past five years much flax seed has been grown in the irrigated districts of California and two years ago flax moved into Texas. Last year many thousand acres produced a profitable crop, and it is predicted that in 1940 the acreage will be greatly increased. We know how to harvest the seed crop, but we have made little progress in handling the straw. Flax, from which linen fiber is produced, is customarily harvested by hand and the entire process of preparing it for the spinner is a hand process. We know how to grow long-fibered flax; it is being successfully done in Willamette Valley in Oregon. Some day, with the help of agricultural engineers, we shall grow the fiber and make our linen thread at home.

Cigarette paper must burn freely, but not too freely. It must burn without odor. It must have strength. Until this year most of our cigarette paper has been imported from France where it is made from linen rags gathered from the four corners of the earth. On September 1, the day the second European war started, a $4,000,000 cigarette paper plant began operations near Asheville, North Carolina, and now one and one-half carloads of cigarette paper are leaving the plant every day—paper made from flax straw grown in California and Minnesota. This straw nets the farmer some $4 an acre, which, added to the value of the flax seed, makes the crop that much more profitable to the grower. We have proven our ability to transfer a $20,000,000 paper industry from war-disturbed France to our own country.

Some five years ago 20,000 acres of tung trees had been planted in the gulf states and many of these plantings were experimental. But one mill for the extraction of tung oil had been erected. Today some 200,000 acres of tung trees are approaching the bearing age, and eight tung oil mills are operating throughout the tung tree territory. Last year 20,000,000 lb of tung nuts were grown, from which approximately 4,000,000 lb of tung oil were extracted. Labor costs in handling the tung crop are too high. Methods must be developed for gathering the nuts, and improved processes for extracting the oil and using the residues and wastes are much needed. The tung oil industry is just started. Twenty-five years from now it may be as important a crop in many sections of the South as the citrus crop.

The difficulty of importing tung oil—and we have been bringing in some 150,000,000 lb a year—due to the war in China and to disturbed ocean shipping, has greatly stimulated the commercial development of quick-drying oils which will take the place of tung oil.

OPPORTUNITY FOR LOWERING COSTS IN CASTOR BEAN PRODUCTION

For some time it has been known that the chemical formula of castor oil could be changed by certain catalytic and chlorination processes which remove a hydroxyl group and leave a product slightly diminished in weight by the amount of water taken out, which looks like tung oil, tastes like it, jells like it, and dries to the same type of film. Within the last two years the paint and varnish industry has imported increasing quantities of castor beans and oil, and it now appears probable that in the years to come we shall utilize castor oil as an important constituent of our paints and varnishes. But it is not necessary to import either the beans or the oil for the castor plant grows in nearly every state. It has long been one of our farm crops, although today, because of the trouble in harvesting the bean, it is of minor importance. This past season some thousands of acres of the castor bean plant have been planted experimentally.

In the Trinity Basin region of Texas the castor bean grows in a few months to the size of a young tree, with a stem several inches in diameter and twenty feet tall. This plant, it is suggested, has valuable uses aside from the importance of its seed crop, and experiments are now under way looking to the separation of the long fiber which may be suitable for cordage, and the conversion of the remainder of the stems and straw into wood pulp for the paper industry. If the yield of fiber and pulp justifies this development, machinery and methods must be adapted for handling it. Perhaps of even greater importance is the possibility that the plant breeder can produce a castor plant from which the beans can be harvested with a modified combine. If this can be done, and if satisfactory yields can be produced, farmers over a wide area will have another new crop which may, like the soybean crop, take the place of acres now growing surplus corn and wheat.

Another crop of some importance is safflower. Commercial acreages of safflower have been grown this year in California, Montana, and New Mexico. It may well be that this Russian crop can be brought to this country and made an important oil crop. Machinery for handling the crop must be built to fit the need.

Lallemantia oil is another new oil which we import from Russia. It is being grown experimentally in the Northwest with every promise of success. It is described as a "glorified" linseed oil.

Rape seed, mustard seed, and sunflower seed may be readily grown over wide areas of our lands. They are not grown because we do not yet know how to handle them profitably. It may well be that ten years or twenty years from now they will be relatively important oil crops.

In the development of the chemurgic program we have given attention to two waste materials which should have very important applications. These materials are the lignin which makes up some thirty per cent of the total weight of wood, and furfural derived from corn cobs, oat hulls, rice hulls, and from most annual fiber crops. A considerable use has been found for furfural, and it is estimated that present furfural production uses some ten per cent of the oat hull tonnage. But the outlet for furfural is still limited to its use in the purification of oils, chiefly mineral oils, and as a plastic material. Research done at the University of Missouri has shown that it can be successfully utilized as a road building material. Lignin, with somewhat similar plastic properties, has also been used experimentally for binding the aggregate used in building secondary roads. It may be that engineering research in the field of road building, which up to the present time has shown little interest in using these new binding materials, will some day discover important values in the lignin from wood and the furfural from farm wastes.

It is these potentialities which are being discovered in research laboratories and developed in pilot plants which will some day contribute largely to the solution of farm problems. We recognize the fact that chemurgic farming must travel a narrow road, avoiding, on the one hand, excursions which are economically unsound, and, on the other, the creation of belief that the promise of large industrial markets for surplus crops will soon be realized.

IMPORTANCE OF RAW MATERIAL SUPPLY IN PROCESSING OPERATIONS

Many chemurgic enterprises have been carefully worked out in research laboratories and perfected in pilot plant operations only to fail in commercial practice. Plants for making alcohol from wood wastes, sawdust and cull lumber, a perfectly feasible chemical procedure, have been built in the South and in the Northwest. I know of two such plants which operated for a short time and then were closed with losses in the millions to the investors. In both cases the failure was due to the fact that the sources of raw material, mountainous as the sawdust piles looked to those who promoted the plants, were soon exhausted. The great cornstalk paper plant built a few years ago at Danville, Illinois, in which several millions of dollars were invested, was built after chemists, engineers, and paper experts had approved the plans and checked every process, except the last and most important one, that of converting cornstalks into cellulose for paper and rayon at a profit. And so after everything had been made ready to divert paper-making practice from the forests of Canada and Sweden to the corn belt, the whole magnificent venture was unsuccessful.

But this need not be taken as a proof that it may not some day be entirely practical to use waste cornstalks and many other waste fibrous crops for paper making.

These reports of chemurgic failures are offset by the astonishing progress of more successful applications of chemical engineering. The chemical processing industries are based upon the conversion of raw materials into a great variety of valuable products. For their raw materials they go to the mine for ores and for fuel, they go to the farm and forest for annual crops and the annual growth of wood. Last year the chemical industry paid farmers $850,000,000 for raw materials from the annual harvest and $300,000,000 for wood and timber, which is a farm crop just as definitely as is corn.

The variability in farm produce prices will automatically diminish as chemurgic industries take larger and larger proportions of the total farm crop and present uncertain crops are replaced by others less affected by adverse weather conditions. Stabilization of farm product prices at levels mutually satisfactory to grower and user depends upon large industrial markets, and the development of these markets is dependent upon stable material prices. Discovery of the solution for this basic problem becomes the most urgent question before the Farm Chemurgic Council and the conversion and processing industries.

ENGINEERING AS AN AID IN COMPETING FOR THE DOMESTIC MARKET

What is being done with soybeans and corn, with wood and its lignin wastes, with sweet potatoes and dairy by-products can be and will be done with all of our crops which produce fermentable starches and sugars; which contain fibers of cellulose, whether they are cotton or wood or hemp or flax; which are rich in proteins for plastics and oils for paints. And there will remain new crops to be grown on millions of acres, crops which now keep foreign labor busy while our own workers look for jobs, such as tung trees along the Gulf Coast, cork which comes to us from war-torn Spain but which should be an important California crop, pyrethrum for insecticides which we can easily grow at home but which we will continue to import from Japan until we develop harvesting implements, medicinal and perfume plants which need only machines to take the place of cheap and nimble fingers of foreign workers, tannins needed to make our leathers which should be a domestic instead of an imported crop, flax and hemp fibers which our own farm lands will produce in ample volume whenever we decide to make our own lines and cordage instead of going to Asia for jute, Mexico for sisal, and Ireland for linens.

All of these new crops and a score of others can be profitably grown at home just as soon as the farmer, the engineer, and the industrialist realize that they have a common problem which, though easy to understand but less easy of accomplishment, is still certain to be solved.

The National Farm Chemurgic Council has not engaged in research work. It has believed that the federal and state governments and private industry is equipped with laboratories and with men able to carry on necessary research work. It feels that its purpose is to stimulate research work, perhaps on occasion to direct the interest of investors into new fields, and always to emphasize the necessity for carrying on studies in every field which will find new uses for the farmer's crops of starch and cellulose or to help him to divert land now growing surplus crops to new and non-competitive crops.

The Chemurgic Council makes no claims for new achievements. It is satisfied to be of help in bringing into closer relationship the farmer whose land and labor are not fully occupied, the scientist who is seeking to apply new truths, and the industrialist who realizes that every pound of a farm crop which finds a use in his factory puts new money in the hands of the farmer and opens a wider market for the products on which our whole economy rests.

NEWS

Washington News Letter

from AMERICAN ENGINEERING COUNCIL

RECLAMATION PROGRAM PROPOSED

RESPONDING to a request by Senator Carl Hayden of Arizona, Secretary of the Interior Harold L. Ickes recently declared that adequately to meet present demands for irrigated land the Bureau of Reclamation could well spend from $50,000,000 to $60,000,000 during each of the coming five fiscal years in the construction of regular reclamation projects of which the costs are fully reimbursable by those benefitting, as well as non-reimbursable expenditures of from $5,000,000 to $7,000,000 per year to supplement additional repayable annual amounts of approximately $5,000,000 on the recently-inaugurated program for the construction of special projects in the Great Plains area.

Senator Hayden's request was prompted by the fact that certain parts of the Great Plains area were suffering from the most severe autumn drought in recorded history. Unless conditions change radically, this will mean during the coming summer a marked resumption in the tide of emigration from this area that has already witnessed the departure of an estimated 100,000 farm families. Pointing out that during 1939 relief expenditures in the 17 states affected by the drought by the WPA alone amounted to over $359,000,000, Senator Hayden suggested the possibility that larger expenditures for reclamation work in this area might result in a material curtailment of the future relief load.

PENDING LEGISLATION

Rivers and Harbors. The Senate has recommitted to its committee on commerce H. R. 6264, reported last June with authorizations totalling $407,855,600, because of the enormous increase over the $83,848,100 authorizations in the bill as passed by the House. *(Continued on page 116)*

Fletcher Heads Important A.E.C. Committee

IN addition to being the representative of the American Society of Agricultural Engineers on American Engineering Council, Leonard J. Fletcher was recently appointed chairman of the A.E.C. Committee on Engineering Economics, which was organized a number of years ago under the guidance of Ralph E. Flanders and which has done some excellent work in pointing out sound economics for the guidance of public affairs. The personnel of the committee is made up of outstanding members of the engineering profession, including such men as Dr. Wm. McClellan, Dr. Harvey N. Davis, Dr. Ralph E. Flanders, H. E. Riggs, D. C. Jackson, and L. P. Alford.

Also, Mr. Fletcher begins his second year as treasurer of American Engineering Council, and as such is a member of the Executive Committee.

Electric Fence Controller Bulletin Available

"ELECTRIC Fence Controllers with Special Reference to Equipment Developed for Measuring Their Characteristics" is the title of a 48-page bulletin F. Alton Everest, assistant professor of electrical engineering, Oregon State College. It is published as Bulletin Series, No. 11, of the Oregon Engineering Experiment Station. It includes a description of typical fence energizer circuits, theoretical considerations of the inductive type of electric fence controller, photography of random transients by means of the cathode-ray tube, measurement of the quantity of electricity in electric fence controller impulses, voltage dividers for transient phenomena, a high-voltage vacuum tube volt meter, the artificial fence, and supplementary illustrations, tables, and appendices.

Silo Makers Approve Results of Silage Pressure Studies

SILO manufacturers have given their approval to the results of silo pressure studies carried on cooperatively by the Bureau of Agricultural Chemistry and Engineering and the New Jersey Agricultural Experiment Station. The investigators found that when silos are filled with grass silage the lateral pressure on the walls is from 1⅓ to 2 times as much as when they are filled with corn silage. Since many farmers are now making use of grass silage, this fact has become of high importance to those building new silos or planning to use old ones for the newer silage. Farmers planning to store grass silage in old silos may need to provide additional reinforcement.

The executive board of the National Association of Silo Manufacturers recently passed a resolution that the association "adopt and recommend reenforcing schedules for farm silos for corn, grass or other forage crops, in accord with data, findings and chart entitled 'Silo Investigations' as issued by the United States Department of Agriculture."

Farmers' Bulletin 1820, "Silos—Types and Construction," issued last spring contains information on the higher pressures of grass silage and the additional reenforcement that may be needed, as well as general information and methods of construction for all the well known kinds.

A.S.A.E. Meetings Calendar

June 17-20, 1940—Annual Meeting, State College, Pa.

August (last week, tentative)—North Atlantic Section, Orono, Me.

December 2-6, 1940—Fall Meeting, Chicago, Ill.

Personals

R. R. Parks has prepared "A 4-H Club Manual For the Farm Electricity Project" and a record book for the use of club members enrolled in the project.

R. H. Reed is author of papers on "Moisture Content of Field Corn," "Conveying and Elevating Systems for Seed Corn Plants," and "1939 Notes on Corn Grading" which are published as mimeographs by the University of Illinois.

F. D. Yung presents "Studies of Insulated Electric Brooders" in agricultural engineering progress report No. 6 (January 1940) of the Nebraska Agricultural Experiment Station.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the February issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Hermon R. Atkins, farm manager, North Hero, Vermont.

James S. Boyd, graduate assistant in agricultural engineering, A. & M. College of Texas, College Station, Tex.

Earle A. Cole, associate agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 276, Billings, Mont.

M. Glen Kirkpatrick, associate editor, Farm Journal, 230 S. Seventh St., Philadelphia, Pa.

Lester F. Larsen, assistant professor of agricultural engineering, South Dakota State College, Brookings, S. D. (Mail) 919 Seventh St.

W. A. Marsh, sales manager, barn equipment division, H. D. Hudson Manufacturing Co., Chicago, Ill. (Mail) 1524 S. Prospect Ave.

Vincent McKeever, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) CCC Camp, SCS-WVA-10, Milton, W. Va.

Fred M. Overby, architect, General Timber Service, Inc. 2391 First National Bank Bldg., St. Paul, Minn.

Lester J. Pfister, owner and manager, Pfister Hybrid Corn Co., El Paso, Ill.

C. G. Plested, sales promotion and service man, George White & Sons Co., Ltd., London, Ont., Canada. (Mail) 477 Burbrook Place.

Robert H. Rea, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 547, Mt. Pleasant, Tex.

Bernard D. Reynolds, Jr., project engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Box 628, Uvalde, Tex.

Robert W. Smith, designer and constructor, John T. Smith & Sons, Tolono, Ill.

Stuart J. Swensson, secretary and treasurer, American Hot Dip Galvanizers Association, Inc., 903 American Bank Bldg., Pittsburgh, Pa.

TRANSFER OF GRADE

F. W. Peikert, associate professor of agricultural engineering, University of Georgia, Athens, Ga. (Junior to Member)

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers thereof, whose names and addresses may be obtained on request to AGRICULTURAL ENGINEERING, St. Joseph, Michigan

BLACK LANDS EXPERIMENTAL WATERSHED—GROUND WATER GRAPHS, 1936-37, *W. D. Potter, H. R. Blank, and C. E. Ramser.* (Coop. Tex. Expt. Sta.) U. S. Dept. Agr., Soil Conserv. Serv. (1939), SCS-TP-24, pp. [2], pls. 20. The Black Lands experimental watershed comprises about 5,000 acres of gently rolling farm land drained by Brushy Creek and located about 15 mi southeast of Waco, Tex. The maximum relief is about 130 ft, the valleys are broad, and the slopes seldom exceed 6 per cent. The underlying geological structure is briefly indicated.

At the end of 1938 some 240 auger holes, bored by hand, 8 to 16 in in diameter, and generally from 15 to 25 ft in depth, had been made; and 113 of them had been converted into permanent observation wells by casing with a 6-in pipe having slot perforations near the lower end. Manual measurements of groundwater levels were made wherever water was encountered in the auger holes. In the cased and preserved holes, measurements were made at intervals of 2 or 3 days up to the present time. Measurements at the same or less frequent intervals were also made on 55 farm wells in the area, particularly on those not in regular use for water supply. Twenty-two Friez FW-1 type water-level recorders have been installed, most of them on the cased auger holes. Graphs show the elevation of the water in 84 open and cased auger holes during the water year 1936-37, as plotted from the manual measurements, only 2 recorders having been installed during this period. Locations of wells are shown on accompanying maps.

THE SOCIAL EFFECTS OF RECENT TRENDS IN THE MECHANIZATION OF AGRICULTURE, *C. H. Hamilton.* Rural Sociol. 4 (1939), No. 1, pp. 3-19. The high point in the manufacture and sale of farm tractors and other farm equipment in the United States was reached in 1937, when the value of such equipment sold by manufacturers for use in the United States amounted to $507,146,913. A recent survey of 3,000 farms shows that 40.3 per cent of the tractors on farms and ranches in the United States were bought in the 3 yr preceding 1938. Temporarily, mechanization increases the individual farmer's income; but ultimately, if mechanization actually lowers cash costs he is forced to cut his prices and at the same time pay higher costs for land and fixed costs for land, machinery, and motor fuel. The farmer also loses some of the advantages of mechanization through continually rising standards and costs of living. The author expresses the view that the mechanized farmer and machinery manufacturer have shifted a lot of their costs to the shoulders of the state, and that new governmental functions, such as the social security, farm security, agricultural adjustment, works program, and housing program are the fruit of poorly controlled mechanization in both industry and agriculture. Another social effect of mechanization and other technological changes is that a larger and larger percentage of agricultural products going into the market is being produced by a smaller and smaller percentage of the farm population.

THE ACCURACY OF PRESSURE GAUGES USED ON HOUSEHOLD STEAM PRESSURE COOKERS, *A. E. Baragar.* Nebraska Sta. Res. Bul. 99 (1938), pp. 18, figs. 3. In addition to a study of the accuracy of 52 new and used pressure gages, other phases investigated were the proper functioning of the safety valve, the methods of sealing the lid to the cooker, the evacuation of air from the cooker, and the use of a thermometer as a temperature indicator.

For testing the gages a 12-qt cooker was fitted with a U-tube mercury thermometer, a copper-constantan thermocouple for measuring the temperature inside the cooker, a ball-and-socket type of safety valve, an automatic air-release valve, a petcock, an opening for the gage being tested, and a copper tubing connected with a mercury manometer which was used as the standard for comparisons and was termed the "master gage." A Bourdon gage was used as a "test gage" in the preliminary tests, but it was found that when the gage was hot the indicated pressure was higher than the actual pressure in the cooker. The gages were grouped into class A, in which the Bourdon tube is coupled to the dial pointer by a lever and a gear operating a small pinion with a hair spring, and class B in which the coupling is made simply by a lever. The dial scale is calibrated in divisions of 1 lb in class A and of 5 lb per square inch in class B gages. The test procedure consisted in heating the cooker so that to cause a difference of 5 lb pressure required about 4 min for the class A and 2-3 min for the class B gages. Temperature and pressure readings were taken for each pound on class A and for each 5 lb on class B gages from 0 to 20 lb. The gage readings were compared with the pressures determined from the manometer and with those calculated from the thermometer temperatures. The release and closing pressures of the safety valves were checked with a calibrated Bourdon-type gage. Pressure cookers with the gage substituted by an assembled checked gage and tire valve were sealed, immersed in water, and by means of a tire pump a pressure inside the cooker of 20 lb per square inch was attained. The presence of leaks was demonstrated by the time rate of decrease in pressure and the production of bubbles.

The master gage proved to be about 8 times as sensitive as the thermocouple and 10 times as sensitive as the thermometer in determining the actual pressures. A study of 12 new class A gages demonstrated the possibility of constructing gages accurate with ± 0.5 lb per square inch. Using that figure as the limit of correct calibration, only 11 of 40 other gages tested were accurate at 5 lb pressure, 5 at 10 lb, 7 at 15 lb, and 8 at 20 lb pressure per square inch. The safety valves in 6 of 11 cookers tested blew off satisfactorily at pressures of from 18.5 to 24.1 lb, while the other 5 began to leak at pressures below the release pressures. The closing pressures ranged from 7 to 21.5 lb. Of 10 new cookers 8 leaked at the safety valve at pressures of 18 and 20 lb, 7 leaked slightly and 2 badly around the rim, and 2 had slow leaks from the petcock. The type of cooker which has the cover clamped on by a band with one bolt was the easiest to seal. The automatic air release valve which was installed in the cooker proved satisfactory to insure complete exhaustion of the air.

YOUR PRESSURE COOKER: HOW TO CHOOSE IT AND HOW TO USE IT FOR CANNING, *A. E. Baragar.* Nebraska Sta. Circ. 57 (1938), pp. 14, figs. 15. This circular contains information based upon the results of the study noted above. In choosing a pressure cooker the most important points are considered to be the size and shape, the material from which it is made, the method of sealing and clamping, the type of pressure gage, safety valve, and petcock, and the possible use of a thermometer. In using the pressure cooker for canning the nonacid foods, the gage pressure should be increased ½ lb per square inch for each additional 1,000 ft at altitudes above 1,000 ft, the pressure gage should be checked at the beginning of each canning season, and the temperatures indicated on the pressure gage should not be used as indicators of the processing temperatures, since these temperatures are correct only for processing at sea level with an accurate gage. While the thermometer cannot replace the pressure gage, the cooker may be equipped with a thermometer as well as a gage if it is desired to process in terms of temperature readings.

A brief outline of the general procedure for processing foods in the pressure cooker is included.

STORAGE OF SUGAR BEETS UNDER CONDITIONS OF HIGH HUMIDITY AND LOW TEMPERATURE, *J. O. Gaskill and H. E. Brewbaker.* (U. S. D. A. and Colo. Expt. Sta.) Jour. Amer. Soc. Agron. 31 (1939), No. 2, pp. 109-115, figs. 4. Sugar beet roots saved for seed production were kept during five winter storage periods with negligible loss from rotting in open crates, without coating or packing material, by maintaining the temperature of the root cellar a few degrees above freezing and the humidity near saturation, and by providing for thorough air circulation. Sugar beets stored 0, 41, 84, and 125 days in the cellar, or 125 days in an outdoor pit-silo, did not differ significantly in root weight. Gradual but statistically significant decline in sucrose percentage occurred with the longer storage periods. The sucrose loss averaged 0.04 per cent per day, attributed largely to respiration. Comparison of cellar-stored and pit-siloed roots after 125 days' storage indicated equivalent behavior. The cellar storage method as described is convenient and efficient for storing small lots of sugar beet breeding strains.

(Continued on page 118)

LIQUID-TIGHT, FATIGUE-RESISTING

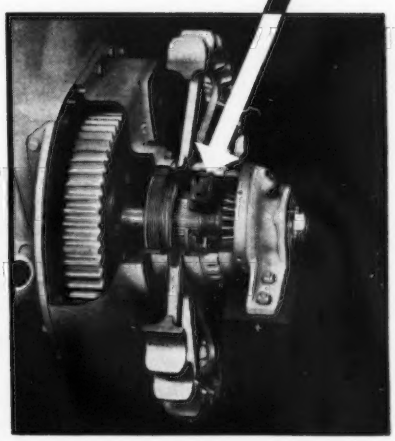
Automatic Bellows Seals!

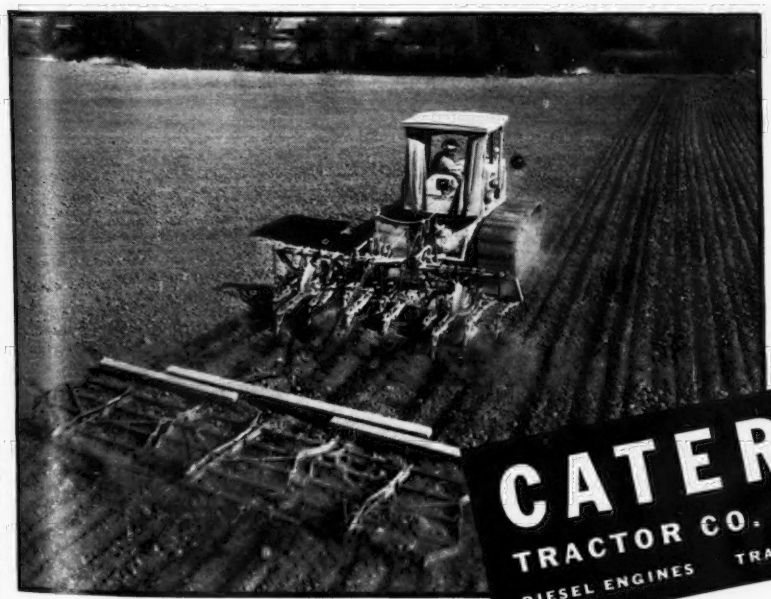
The gland type final drive seals which "Caterpillar" formerly used stood out in their day. But they did require adjustment—did surrender to water—and did cause excessive friction.

It was to overcome these shortcomings that "Caterpillar" developed today's copper bellows seal. By the laboratory processes of combination and elimination of materials the present design evolved.

Cork became the sealing surface—because of its ability to absorb lubricant and slide freely on smooth metal surface. Chromium plated washers became the surface against which cork effects the seal—because of the high resistance of this plating to wear and corrosion. The bellows of copper resists corrosion and fatigue, provides the proper degree of flexibility between sealed members—to "take up" itself for wear and be fully automatic. Leather proved itself to be the proper backing for the cork. And individual steel springs are provided, to press the sealing surfaces together—and thus to maintain a positive, liquid-tight connection.

So effective are "Caterpillar" bellows seals that they exclude dust, mud and water—and retain lubricant—even under extreme operating conditions. And these fully automatic bellows seals typify the extra care and expense to which "Caterpillar" goes—to build extra life, dependability and value into "Caterpillar" Products.





CATERPILLAR

TRACTOR CO. • PEORIA, ILLINOIS

DIESEL ENGINES TRACK-TYPE TRACTORS TERRACERS

BCA puts
MORE PROTECTION here
for LONGER SERVICE here

"MORE SPACE for the lubricant" provided by BCA's new Composition Seal Bearing has an extra plus value in farm machinery.

The generously enlarged space for the lubricant on both sides of the balls is an added protection against neglect and eventual failure which shrewd designers of agricultural machinery have been quick to give a vote of approval.

The composition seals of these "Greased Lightning" ball bearings keep out dirt, retain the lubricant and permit a freer-running bearing because they exert less pressure on the rotating surfaces than any other seal bearing made.

BCA Composition Seal Bearings on your agricultural machinery is an assurance of longer trouble-free service in the field.

BEARINGS COMPANY OF AMERICA • LANCASTER, PENNA.

BCA

RADIAL • ANGULAR CONTACT • THRUST

BALL BEARINGS

Washington News Letter

(Continued from page 113)

Registration of Engineers. The House committee on the District of Columbia will hold additional hearings on S. 1128, which provides for registration of engineers in the District. A good deal of opposition has arisen to the legislation on the grounds that its provisions are too drastic.

Water Pollution Control. Following the suggestion of the President, legislation proposing to create a Division of Water Pollution Control in the U. S. Public Health Service, is being studied by the Reconstruction Finance Corporation, with a view to suggesting amendments that would place the making of loans for projects under the act in the hands of the R. F. C. instead of the Treasury Department.

Civil Service Extension. The Ramspeck bill, H.R. 960, which authorizes the President to cover into the classified civil service by executive order positions in executive departments, independent establishments or other agencies of the federal government (with certain exceptions), passed the House of Representatives February 9, amended to exclude employees not now under civil service from states whose quota of positions in the classified civil service is more than filled. The legislation is pending before the Senate committee on civil service.

Employment of Engineers and Architects. H. R. 7635, introduced by Mr. Alexander and referred to the House committee on public buildings and grounds, provides that any department or bureau may employ competent professional engineers or architects in private practice to prepare or to assist in preparing designs, plans, and specifications for new buildings and other structures, and compensate them for such services. The bill further provides that government agencies may also employ such consultants to prepare alternate designs, plans, and specifications for new buildings or other structures which are estimated to cost $200,000 each, or more, under the following conditions: The government agency to pay the out-of-pocket cost of preparation of the alternate design, including only labor, material, supplies, general office overhead expense, and necessary travel and sustenance, but no compensation for principals. Said alternate designs are to be advertised and submitted for bids at same time and under same conditions as base plans prepared by department or bureau staffs. If low bids on the alternate design, compared with low bids on the base plans, show a gross saving to government equal to or greater than twice the amount of the full fee of the private engineers or architects who prepare them, including their out-of-pocket costs, the government shall pay them the full fee.

Council has received several inquiries about this legislation and the author of the bill reports widespread interest among architectural and engineering societies. One important government agency has made an adverse report on it. To date the House committee on buildings and grounds has made no plans for hearings.

* * *

A.E.C. CHANGES QUARTERS

Effective February 15, American Engineering Council shifted its offices in Washington from the old quarters which it had occupied since 1922 to a new location at *919 Seventeenth Street, N.W.,* where it will occupy a building jointly with the American Forestry Association and immediately adjoining the Army and Navy Club.

TNEC STATES PLANS

Having given recent consideration to the characteristics of cartels and completed hearings on steel and life insurance, the Temporary National Economic Committee through its chairman, Senator Joseph C. O'Mahoney of Wyoming, has announced its plans for winding up the inquiry, which began late in 1938.

Additional hearings will be held on at least three subjects: interstate trade barriers; the impact of technological development upon employment; and, finally, an economic free-for-all at which the Committee will listen to witnesses desiring to present ideas for the solution of economic problems.

In its investigation of technical change the Committee is expected to examine a number of fields of business, and particularly the machine tool industry. Much basic material is available as the result of a comprehensive study of this question that has been under way for several years under the sponsorship of the research division of the Works Projects Administration.

In planning the final sessions the Committee recognizes that it will be impossible to hear all witnesses that will volunteer, but hopes to receive applications for time from "responsible students, and particularly from institutions and groups which have utilized their resources for special studies."

Starting about March 1, the Committee will present to Congress a number of special reports prepared for it by its own staff and by other federal agencies that have been cooperating. The final report of the Committee itself will not be prepared until after the close of hearings about June 1, and will not be finished until November, 1940, at the earliest. It will analyze and summarize the numerous hearings and reports, in a transcript of about 80 volumes.

REMEMBER WHEN HIGH COMPRESSION GOT THE HORSE LAUGH?

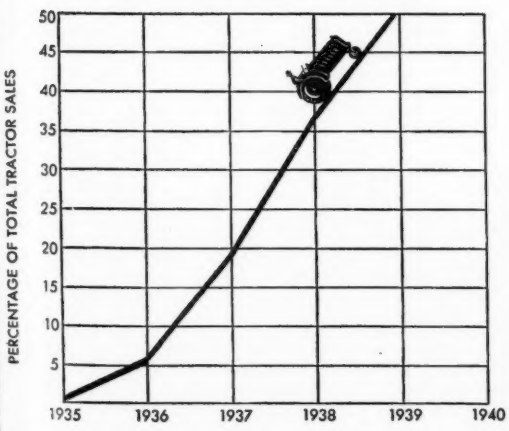
HERE is another important indication of the rapid swing to high compression. A recent survey in three leading tractor counties in Illinois—Livingston, McLean and Champaign—showed that in 1939 over fifty per cent of all tractors sold were high compression models. Quite a jump when you consider that in 1935 high compression sales represented only 1-3 of 1%!

What's back of this landslide to high compression? Simply this:

Farmers know that high compression tractors deliver more useful power for their weight, size and *cost!* They know that high compression plus good gasoline gives them flexible farm power that can be easily adjusted to the load and speed requirements of various types of farm jobs. They know that good fuel and better combustion saves on oil dilution, and ends the nuisance of frequent radiator curtain adjustments. And this knowledge is everywhere being reflected in a demand by farmers for high compression tractors.

Remember, when you're selling a high compression tractor you're working with the tide . . . giving the farmer the kind of machine he wants in order to do his work faster and better . . . and in the long run he'll appreciate your selling him a tractor that will still be up-to-date years from now. Ethyl Gasoline Corporation, Chrysler Building, New York, N. Y.

FIVE YEAR TREND OF HIGH COMPRESSION SALES IN 3 LEADING TRACTOR COUNTIES OF ILLINOIS



TUNE IN EVERY MONDAY NIGHT—Tony Martin, Andre Kostelanetz and his orchestra, featured on "Tune-Up Time" over coast-to-coast network, Columbia Broadcasting System.

SELL MORE HORSEPOWER AT LESS COST THROUGH

HIGH COMPRESSION

Can you answer these questions on Galvanized sheets?

You will find it interesting to check these questions and compare your results with the answers below.

1. ***Why is zinc used to coat iron and steel sheets?***
2. ***What is meant by weight of coating?***
3. ***What zinc-coated sheet can be safely drawn and severely formed?***
4. ***Can galvanized sheets be soldered successfully?***
5. ***Can galvanized sheets be welded successfully?***

1. *Zinc* **is applied to iron or steel sheets to protect them from corrosion. Zinc is the commonly preferred metal because it is economical and tends to sacrifice itself to protect the iron or steel.**

2. *Weight of coating* **applies to the weight of galvanizing on an iron or steel sheet, in ounces per square foot. For example, a 1.50-ounce coating means .75-ounce coating on each side of a square foot of sheet metal.**

3. ARMCO ZINCGRIP is a special galvanized sheet that can be severely drawn and formed into farm equipment without peeling or flaking. Poultry feeders and waterers, hog waterers, sprayer tops, hammer mill dust collectors, and many other products are examples. Special processing also gives ZINCGRIP a bright, attractive appearance, and makes it stronger than ordinary galvanized sheets of the same gage.

4. *Since soldering* **takes place at relatively low temperatures, and is essentially a bonding of the coatings, galvanized sheets can readily be soldered and ordinary methods will not harm the galvanized coating.**

5. *When care is taken,* **galvanized sheets can be spot welded or electric arc welded and the corrosion resistance at the weld will not be materially impaired. If the burned area is large it can be covered with a special coating to inhibit corrosion.**

These are only a few of the questions covered in our technical engineering bulletins on galvanized sheets. In requesting these bulletins, please write on your company letterhead or mention your affiliation in the coupon below.

ARMCO

ZINCGRIP

THE MODERN METAL FOR THE FARM

MAIL THIS COUPON

THE AMERICAN ROLLING MILL CO., 871 Curtis St., Middletown, Ohio
Please send me your technical bulletins on galvanized sheet metal.

*Name*_____

*Company or affiliation*_____

*Address*_____

*City or town*_____ *State*_____

Agricultural Engineering Digest

(Continued from page 114)

THE FLOW OF WATER IN THE MAIN DIVERSION FLOODWAY OF THE LITTLE RIVER DRAINAGE DISTRICT IN SOUTHEAST MISSOURI. *C. E. Ramser.* U. S. Dept. Agr., Soil Conserv. Serv. (1939), SCS-TP-22, pp. [17], pls. 7. It is noted that although floodways are quite commonly used for flood control, but little reliable information upon which to base their design is available. The investigation here reported upon had the primary purpose of evaluating the coefficient of hydraulic roughness, "*n*," in the Kutter formula for cleared and uncleared floodways, and of obtaining related data of value in studies of the hydraulics of floodways. The experiments were made on the main diversion floodway of the Little River drainage district in southeast Missouri. Field surveys were begun in November 1921, and most of the hydraulic data were obtained during the spring of 1922 during a flood stage in the Mississippi River. Following a brief description of the floodway studied, the author details the methods used in making discharge measurements, slope measurements (in which the utmost care was necessary because of the susceptibility of such slope measurements to large errors capable of making the final results inaccurate), cross-section measurements, and in the computations. On the basis of the data presented, he discusses velocity between channel and floodway, comparative values of *n* for different widths of floodway, flow of water in floodway channel, Kutter's *n* for floodway channel, combined flow in channel and floodway, etc.

The experiments showed, among other results, that where the channel is not located in the center of the floodway the value of *n* for the floodway on one side of the channel may not be the same as that for the other where the distance from the edge of the channel to either of the levees is small. In one set of measurements, the value of *n* obtained for the main floodway north of the channel was 0.0462, for the berm south of the channel 0.0366, and for the channel 0.0329. The lower value of *n* obtained for the berm south of the channel is attributed to the accelerating influence of the channel velocities. "The narrower the floodway the greater will be this influence upon the value of *n*. Hence it is seen that the value of *n* to be used in computing the flow on the narrow berm will likely lie somewhere between the values assumed for the channel and the main floodway. It is advisable, however, in order to be on the safe side, to assume the same value of *n* for the berm as for the main floodway."

RESPONSES BY TOMATO PLANTS TO ARTIFICIAL ILLUMINATION. *J. W. Mitchell.* Bot. Gaz. 99 (1937), No. 2, pp. 412-419, figs. 2. Tomato plants, grown beneath a Mazda lamp and beneath a carbon arc light with radiant energy equalized by means of a thermopile placed at the leaf surface in one instance and with a Weston photronic cell in the other, were compared as to dry weight increment and carbohydrate content. Plants beneath the arc lamp grew less in height and synthesized more than twice as much solid matter and approximately four times as much acid hydrolyzable material in a given period as did the Mazda-lighted plants. The author suggests that there may have been radiated from the arc a greater intensity of wavelengths known to accelerate the process of photosynthesis. The use of the photronic cell as an equalizer of radiant energy tended to lessen the differences between the two lots of plants.

INFLUENCE OF TEMPERATURE AND HUMIDITY UPON THE GROWTH OF CHICK EMBRYOS IN A MECHANICALLY VENTILATED INCUBATOR, *R. Penquite.* Iowa Sta. Res. Bul. 232 (1938), pp. 39, figs. 10. In studying the effect of humidity on embryonic growth, eggs were incubated at relative humidities of 40, 62, and 80 per cent and at a constant temperature of 99.7 F. Within this range relative humidity did not exert a significant effect on the growth of embryos as measured by the wet weight, dry weight, or total nitrogen (determined daily from the fourth to twentieth days of incubation). A significant difference was observed on the sixteenth seventeenth, and eighteenth days between the total ash of embryos incubated at the various humidities, indicating that the 62 per cent level was preferable. The dry weight of the embryos was considered the best of these four measurements of growth. "Loss of moisture from the egg during incubation was influenced not only by the temperature and humidity of the egg chamber but also by circulation of air around the egg, shell texture, and the thickness and surface area of the shell. A comparison of incubation temperatures of 104.9 and 99.7 F gave evidence of more rapid growth (dry-weight basis) at the higher temperature during the first 10 days of incubation. Growth rates were practically equal when a mechanically ventilated incubator was operated at 2 deg lower temperature than a sectional-type machine, emphasizing that the type of incubator governs the temperature and humidity at which it should be operated. *(Continued on page 120)*

Now 4 Sizes New

DIESEL TRACTRACTORS *by* INTERNATIONAL HARVESTER

A YEAR AGO we announced the big, powerful TD-18 TracTracTor, a new top for Diesel crawlers. Today International Harvester presents a rugged quartet of streamlined crawlers—TD-18, TD-14, TD-9, and TD-6. FOUR Diesel TracTracTors for 1940—big news from the world's leading tractor builder to ALL operators of crawler tractors!

Here's the complete line-up for you to look over—the big fellow at the right, already a popular favorite in the heavy-crawler field; his little brother at the far left; and the step-ups in between. There's not an ounce of lazy horsepower in any of them! They're ready to tackle their weight in wildcats—each one is ready to lick the crawler-power problems in his range!

In this complete series of TracTracTors, INTERNATIONAL offers you a new standard of Diesel performance and economy—perfectly designed balanced power in capacities to meet every demand of crawler-tractor users. Standardize on International and enjoy all the advantages only Harvester can provide. Get the full story from any International dealer or Company branch, or write us.

INTERNATIONAL HARVESTER COMPANY
(Incorporated)
180 North Michigan Avenue CHICAGO, ILLINOIS

A Handsome, Permanent Binder *for* AGRICULTURAL ENGINEERING

only $1.40

The ONLY binder that opens flat as a bound book! Made of durable imitation leather, nicely stamped on front cover and backbone, with name of journal and year and volume number, it will preserve your journals permanently. Each cover holds 12 issues (one volume). Do your own binding at home in a few minutes. Instructions easy to follow. Mail coupon for full information, or binder on 10-day free trial.

MAIL COUPON TODAY

SUCKERT LOOSE-LEAF COVER CO.
234 West Larned St., Detroit, Mich.

Mail postpaid.....binders for Agricultural Engineering for years.....
Will remit in 10 days or return binders collect.

Name.....

Address.....

City.....State.....

the BADGE of him who BELONGS

DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

But the Society emblem is *evidence* that native talent, be it great or small, is enriched by fraternity with the personalities whose minds fuse to form the pattern of progress in the methods and mechanics of agriculture. The wearer of the emblem waits not for the debut of an idea, but is present at its birth and helps to guide its growth.

Be you novice or veteran, your membership in the organized profession adds something to your efficiency, your vision, your influence as an individual engineer. The Society symbol on your lapel is token that you "belong". Wear it.

STYLES AND PRICES OF ASAE EMBLEMS

With blue ground for Fellows and Members—furnished either in pin with safety clasp or lapel button—$2.00 each.

With red ground for Junior Members, Associates, and Student Members—furnished only in pin with safety clasp—$1.00 each.

Send orders to ASAE, St. Joseph, Michigan.

Agricultural Engineering Digest

(Continued from page 118)

PRECOOLING TESTS OF INDIANA STRAWBERRIES, CANTALOUPES, AND PEACHES, *T. E. Hienton and K. I. Fawcett.* Indiana Sta. Bul. 439 (1939), pp. 36, figs. 23. In these tests 66 carloads of strawberries, cantaloupes, and peaches were included in the precooling tests in Indiana which were initiated in 1933, and have been continued since that time. These were distributed as follows: Strawberries 22, cantaloupes 25, and peaches 19. All of them were precooled with the exception of 6 carloads, used as checks in transit tests, consisting of 1 carlot of strawberries, 2 of peaches, and 3 of cantaloupes. The rate of cooling was faster with 2 disk fans, of 18-in diameter, 1,750 rpm, with 0.75-hp motors, than with other fans used, but was approximately the same as that for 4 bunker blowers, and slightly less than that of a truck unit. The lack of sufficient ice in the bunkers was found to retard the rate of cooling where fans are used. The amount of ice used was 2,200 lb for the precooling of a car of strawberries, 3,500 lb for a car of cantaloupes, and 6,100 lb for a car of peaches, after some cooling had occurred prior to the start of precooling. The amount of salt added to the ice in the bunkers during precooling was found to directly affect the rate of cooling. Time required for precooling can be reduced by increasing the amount of salt used. Four hundred pounds were used without freezing the fruit in the car. Precooling the top layer of a carlot of strawberries to approximately 45 F prevented the development of rot in transit and resulted in higher return to the shipper than for one not precooled. Precooling the top layer of a carload of cantaloupes to 50 F or below will enable the grower to safely market vine-ripe melons at a greater return than for those which are half-slip or less. The rate of precooling of peaches in ventilated baskets, with ventilated liners, and ventilated pads was greater than that in regular bushel baskets. Brown rot development in the top layer of a carlot of peaches is definitely inhibited during transit by precooling to less than 50 F. before shipment.

Literature Received

SIMPLIFIED WIRING, by H. P. Richter. Twelfth edition. Paper bound, 122 pages, 5¾x8¼ in, illustrated, indexed. This booklet, again brought up to date, gives information on how to do simple residential and farm wiring jobs correctly and in conformity with approved codes and regulations. It is also indicated to be of value in planning installations. Subjects covered include underwriters and codes, buying an electrical installation, measurement of electricity, wire sizes and types, fuses, ABC of wiring, the service entrance, four wiring systems, wiring with non-metallic sheathed cable, wiring with armored cable, wiring with conduit, wiring with knob and tube system, miscellaneous wiring, finishing an installation, old-work installations, farm wiring, electric motors, and wiring for home light plants. Park Publishing Co. P.O. Box 774, Evanston, Ill. 25 cents. Lower prices on quantity orders.

REPAIRING FARM MACHINERY, by Ivan G. Morrison. Leatherette binding, 181 pages, 5½x8½ in, 118 illustrations. A suitable text and reference handbook for training teachers of vocational agriculture, for use by students of vocational agriculture, and as an operating manual for farmers. Machinery covered includes mowers, grain binders, walking plows, wheeled plows, disk harrows, spike tooth harrows, spring tooth harrows, cultivators, corn planters, grain drills, side delivery rakes, and corn binders. Interstate Press, Danville, Ill., no price stated.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS WANTED

AGRICULTURAL IMPLEMENT BLOCKMAN, with three years in agricultural engineering work at Kansas State College and ten years' experience with large manufacturer of farm equipment desires position with another similar concern, or in any branch of agricultural engineering, farm management, or agricultural bank. Age 36. Health excellent. No defects or bad habits. Married. Rural background. Complete credentials furnished upon request. Best of references. H. L. Vanderwilt, Eldridge Hotel, Lawrence, Kans.